Identification of Ecologically and Biologically Significant Areas in the Bay of Fundy, Gulf of Maine

Volume 1

Areas identified for review, and assessment of the Quoddy Region

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ABSTRACT

As part of Science contributions to Oceans Management, this report re-evaluates significant areas in the Bay of Fundy previously identified by applying a range of internationally accepted criteria drawn from the scientific literature (Buzeta et al. 2003a). Since then, the Department of Fisheries and Oceans developed National criteria (DFO 2004) for Ecologically and Biologically Significant Areas (EBSAs) that provide consistency in evaluations. This report lists potential areas, and evaluates those within the Quoddy Region for which we have adequate-to-substantial information to apply the new National criteria for EBSAs. Future volumes would provide the details required for evaluations of additional areas.

On February 25-26 2008, a panel of experts and scientists at large convened at a workshop held at the St. Andrews Biological Station, NB, to apply EBSA criteria to areas within Bay of Fundy. This report outlines the approach used towards identification of EBSAs in coastal Bay of Fundy, assesses whether these criteria can be used productively in coastal areas, and reports on the assessment of areas within the Quoddy Region, southwest Bay of Fundy.

Scientists at the workshop considered the Quoddy Region significant, unique, and irreplaceable, for all of the Bay of Fundy, with many specific areas within it identified for EBSA attributes. The Quoddy Region was described as operating as a whole, so there is concern with priority setting for some areas and not others, and therefore there was a strong consensus that the entire Quoddy Region should be managed with caution. However, for management purposes, smaller areas within it were evaluated as EBSAs.

Within the Quoddy Region, The Wolves and Maces Bay were thought to satisfy some of the EBSA criteria, and Head Harbour / West Isles / The Passages, clearly and unquestionably satisfied all the primary EBSA dimensions of Uniqueness, Aggregation and Fitness Consequences. These adjacent areas are considered to be hotspots within the Quoddy Region, and were given the highest priority ranking for protection by all workshop participants.

Head Harbour / West Isles / The Passages as a unit were considered to be ecologically unique and noted for high diversity of benthic fauna. Specifically, the Head Harbour / West Isles area was shown to have higher than average benthic species richness. These species-rich communities were significantly correlated to the habitat characteristics of that area (temperature, salinity, benthic complexity). The Passages were identified for high biodiversity, and for the presence of upright and large encrusting sponges, including new and previously unrecorded sponge species. The analyses provided scientific validation of the experiential knowledge that supports the recommendation of Head Harbour / West Isles / The Passages as Ecologically and Biologically Significant. Of the areas reviewed, these areas had overwhelming and consistent evidence of significance.

This report is meant as a planning tool for managers who must consider the management of a number of present and proposed habitat-altering activities prosecuted in these areas. Based on the fact that Head Harbour / West Isles / The Passages were identified as EBSAs because of their benthic habitat attributes, such activities pose an elevated concern. The consensus of workshop participants was to recommend the application of protection measures for Head Harbour / West Isles / The Passages.

RÉSUMÉ

Le présent rapport fait partie de la contribution des Sciences aux travaux de la Gestion des océans. Il réévalue des zones jugées importantes de la baie de Fundy déjà identifiées, en utilisant une série de critères acceptés à l'échelle internationale et tirés d'ouvrages scientifiques (Buzeta et coll., 2003a). Depuis ce temps, le ministère des Pêches et des Océans a élaboré des critères nationaux (MPO 2004) pour les zones d'importance écologique et biologique (ZIEB) qui donnent de la cohérence aux évaluations. Le présent rapport dresse une liste de zones qui pourraient éventuellement devenir des ZIEB, et il évalue celles situées dans la région de Quoddy pour lesquelles nous possédons déjà des renseignements allant d'adéquats à importants pour y appliquer les nouveaux critères nationaux de désignation des ZIEB. Les futurs ouvrages devraient fournir tous les détails requis pour procéder à l'évaluation de zones additionnelles.

Les 25 et 26 février 2008, un groupe de spécialistes et de scientifiques de plusieurs domaines se sont réunis à la Station biologique de St. Andrews, au Nouveau-Brunswick, pour appliquer les critères de désignation des ZIEB à des zones situées dans la baie de Fundy. Le présent rapport décrit l'approche utilisée pour identifier les ZIEB qui longent les côtes de la baie de Fundy, évalue si ces critères peuvent être utilisés efficacement dans des secteurs côtiers et faire le point sur l'évaluation des zones situées dans la région de Quoddy, dans le sud-ouest de la baie de Fundy.

Les scientifiques à l'atelier ont considéré la région Quoddy significative, unique et irremplaçable, pour toute la Baie de Fundy, avec beaucoup de secteurs spécifiques identifiés pour des attributs d'EBSA. La région Quoddy a été décrite comme faisant fonction d'un ensemble, et pour cette raison il y a des soucis avec la mise de priorité pour certain secteurs et pas les autres. Donc, il y avait un consensus fort que la région Quoddy entière devrait être gérée avec précaution. Cependant, pour des raisons de gestion, des secteurs plus petits ont été évalués comme des EBSAs.

Toutes les zones situées à l'intérieur de la région de Quoddy sont reliées, d'où l'inquiétude que suscite l'établissement d'un ordre de priorité. Les scientifiques sont presque unanimes à dire que toutes les zones de la région Quoddy devraient être gérées avec précaution.

Deux secteurs en particulier sont présumés satisfaire à certains des critères de désignation d'une ZIEB, soit les îles Wolves et la baie Maces. Cependant, Head Harbour, West Isles et les Passages satisfont clairement et sans contredit aux trois critères de base pour la désignation d'une ZIEB, soit l'unicité, la concentration et les conséquences sur la valeur adaptative. Ces zones avoisinantes sont estimées être des zones sensibles de la région de Quoddy et tous les participants de l'atelier leur ont accordé la plus haute priorité en matière de besoin de protection.

Les participants ont qualifié Head Harbour, West Isles et les Passages comme un ensemble écologiquement unique porteur d'une faune benthique très diversifiée. Plus précisément, Head Harbour et West Isles ont été soulignés pour leur abondance d'espèces benthiques supérieure à la moyenne. Ces communautés très diversifiées présentent une corrélation importante avec les caractéristiques de l'habitat de cette région (température, salinité, complexité benthique). Les Passages a été souligné pour sa grande biodiversité et pour la présence de larges éponges encroûtantes verticales, y compris de nouvelles espèces qui n'ont encore jamais été documentées dans cette région. Les analyses ont fourni une validation scientifique de la connaissance expérientielle qui soutient la recommandation voulant que Head Harbour, West Isles et les Passages soient reconnus comme des zones d'importance écologique et biologique. De toutes les zones examinées, celles-là présentaient des preuves impressionnantes et constantes de leur importance.

Le présent rapport se veut un outil de planification pour les gestionnaires qui doivent gérer une foule d'activités actuelles et éventuelles qui risquent de modifier l'habitat de ces zones. Ces activités représentent une source d'inquiétude accrue étant donné que les zones de Head Harbour, West Isles et les Passages ont été désignées comme ZIEB à cause de leurs attributs d'habitat. Les participants à l'atelier étaient unanimes à recommander la mise en œuvre de mesures de protection pour Head Harbour, West Isles et les Passages.

I. INTRODUCTION

Identification of significant areas, using a variety of criteria, is one of many tools for calling attention to areas, and can form part of a strategy for protecting habitats and marine communities. The identification of Ecologically and Biologically Significant Areas (EBSA) facilitates the delineation of zones where protection should be enhanced, while allowing appropriate sustainable activities to occur. Significant areas within the area of influence from marine and coastal activities should be a management concern (Chang et al. 2005). A greater than usual degree of risk aversion in managing these areas will help meet the national objective for ecosystem-based management, which outlines the maintenance of marine productivity, biodiversity, and habitat (DFO 2004; Jamieson and Levings 2001). Meeting the Ecosystem Objectives (EOs) for EBSAs is considered a requirement for meeting those for the larger ocean management area: *"if we are not meeting the EOs for EBSAs, then we are not meeting them for the larger ocean management area"* (J. Rice, DFO, Ottawa, ON, K1A-0E6, GOSLIM EBSA Workshop, February 2006). As well, EBSAs are a tool for Canada to identify areas of high biodiversity, thus meeting national and international obligations towards the conservation of biodiversity and establishment of a system of protected areas (Canadian Biodiversity Strategy 1995).

Marine conservation has traditionally focused on individual species or populations. More recently, conservation of habitat, species assemblages, and hotspots of biodiversity, are also seen as objectives in managing marine areas. For biodiversity, this includes maintaining enough components (ecotypes, communities, populations, species) to preserve the structure and natural resilience of the ecosystem (Jamieson and Levings 2001; Gavaris et al. 2005, Singh & Buzeta 2007). Studies suggest that smaller areas can be chosen for protection based on fish and invertebrate assemblages, while larger ones can be chosen based on habitat categories and regional characterization. If the conservation objective is that of the greatest number of species by protecting the smallest area possible (Hughes et al. 2002), then protecting hotspots of biodiversity can be a cost-effective approach.

Changes in biodiversity as measured by species richness, though by no means a complete measure of biodiversity, can indicate anthropogenically disturbed habitats with linkages to management of marine activities (Valiela 1995; Barnes and Hughes 1999; Mann 2000; Wildish and Stewart 2004). The number of species in a highly disturbed community is typically low, because few populations are able to re-establish under these conditions (Pickett and White 1985; Valiela 1995), and the space made available through fishing disturbance may remain vacant or be colonized by short-lived opportunistic or invasive species (Eno 1996; Kenchington et al. 2006). Recognizing species-rich areas as EBSAs (DFO 2004), and managing them so as to protect the habitats that support the species, will assist Canada in reaching its biodiversity conservation obligations.

Science rarely has a full understanding or sufficient knowledge of ecosystems, but areas can be evaluated for their ecological and/or biological significance with

adequate-to-substantial information (DFO 2004) collated from surveys, monitoring, and the scientific literature, and gathered using the Delphic approach (Strauss and Zeigler 1975) (e.g. workshops, questionnaires, local and expert opinion). DFO acknowledges that assessments of areas will be limited by the availability of data, but the inclusion of experiential knowledge is thought to improve this bias. Experiential knowledge can include traditional ecological knowledge (TEK), local knowledge gathered from years of experience working in the geographic area, and scientific ecological knowledge (SEK) gathered through field experience. When scientific data are lacking, results show we can have confidence in applying the precautionary principle (i.e. err in the side of caution) (United Nations Convention on Biological Diversity 1992), to proceed with conservation decisions, based on expert opinion of scientists, academics and naturalists. For example, expert opinion or experiential knowledge can be used to provide *a priori* classifications or to identify sites considered significant from a species diversity perspective, and subsequent scientific surveys or statistical analyses could verify these assumptions (Appendix 3).

The review of past and present efforts in the identification of ecologically or biologically significant areas, regardless of criteria used, presents an emerging model: scientific information is gathered through the existing literature, and using a Delphic approach the input from experts and workshop participants is obtained, which validates, disputes and/or augments the list of significant areas (Clarke and Jamieson 2006). If evidence for an area's significance is supported/validated by more than one source and is therefore recommended as an Ecologically and Biologically Significant Area (EBSA), information should be considered sufficient for decision-making (Breeze 2004). Previous efforts for the Bay of Fundy (Buzeta et al. 2003a) followed this model, but did not have National criteria available to define "significance". The development of National EBSA criteria (DFO 2004) meant that previous initiatives should be considered preliminary. The information gathered in previous efforts facilitated the EBSA process, but a re-evaluation of areas with new criteria was required.

Many of the terms used in the past to identify "significant" areas were not defined/quantified, or definitions used to evaluate an area focused on anthropogenic values such as significant habitat for an important life stage of a commercial species (Therrien et al. 2001). Many definitions overlapped or could be further subdivided. For example, significant could mean "critical" or "important" (Burt 1997). Additionally, some of the terms have a legislative significance (e.g. *Oceans Act, Fisheries Act*). Examples of previous and ongoing assessments and the criteria used are summarized in Table 1.

Table 1. Criteria used in other assessments of significant areas.

Assessment	Criteria used	Citation
Prince Edward Island and Gulf of St. Lawrence	Regionally significant habitat for marine species, important to specific life stages, biodiversity, specific ecosystem features.	Therrien et al. 2001
Bay of Fundy and approaches	Endangered/threatened species; productivity; unique or ecologically significant; spawning, larval, nursery, or staging area; high biodiversity; education, research, monitoring; recommendations for protection.	Buzeta et al. 2003a
Eastern Scotian Shelf	Productivity, biodiversity, reproductive areas, bottle-neck areas, habitat for species at risk, rare/unique habitats, naturalness, critical area, fragile/sensitive, significance.	Breeze 2004
Bras d'Or Lakes	EBSA criteria: uniqueness, aggregation, fitness consequences, naturalness, resilience.	Westhead et al. 2007
Eastern Scotian Shelf	EBSA criteria: uniqueness, aggregation, fitness consequences, naturalness, resilience.	den Heyer et al. 2006
Pacific North Coast	EBSA criteria: uniqueness, aggregation, fitness consequences, naturalness, resilience.	Clarke and Jamieson 2006
Gulf of St. Lawrence	EBSA criteria: uniqueness, aggregation, fitness consequences, naturalness, resilience.	Rice and Morry 2006

Evaluation of EBSAs must be made with the best information available at the time. Therefore, it is not necessary to evaluate all areas within an ecosystem at the same time. For this reason, Bay of Fundy evaluations will form a series of reports, starting with those areas for which data are adequate for a review.

However, a few considerations must be kept in mind when reading this report:

- Identification of (Ecologically and Biologically Significant Areas) EBSAs was based on information and previously summarized and mapped in Buzeta et al. (2003a).
- Draft boundaries for each site were drawn to facilitate the review purpose, and not to represent management units.
- Identification of EBSAs was meant as science advice to managers for use as a planning tool.
- Management of EBSAs will require additional information (e.g. social, economic) and stakeholder and public participation to identify appropriate tools.

What are Ecologically and Biologically Significant Areas (EBSAs)

In order to standardize the ecological and biological assessment of areas, DFO developed criteria for EBSAs, thereby providing a nationally defined and consistent evaluation method. EBSAs identified would rank highly on one or several of these criteria. There are three main criteria against which areas are to be evaluated (DFO 2004; Clarke and Jamieson 2006):

1) Uniqueness – the degree to which the characteristics of areas are unique, rare, distinct, and have few or no alternatives.

2) Aggregation – of individuals of a species, of different species, of structural features, of oceanographic processes.

3) Fitness Consequences – the degree to which the area is required by a population or species for various life stages and activities.

Two additional modifying criteria are to be subsequently applied:
5) Resilience – the degree to which habitat structures or species are sensitive, easily disturbed, or slow to recover.

6) Naturalness - degree to which areas are pristine and contain native species.

Evaluations must consider:

- Biological functions (e.g. spawning, rearing, feeding, migration)
- Physical oceanography (e.g. upwellings, convergences)
- Structural habitat features (e.g. complexity, rocky reefs, sponge reefs)
- Biodiversity (e.g. species at risk (SAR), genetic, species, assemblages, habitats)

EBSAs are considered to be:

- A management planning tool and an aid in reaching ecosystem objectives (productivity, habitat, biodiversity) for a management area.
- Areas that should not be perturbed and that require a higher level of risk aversion (i.e. managers should emphasize conservation and enhance protection).

- A scientifically justifiable starting point for Marine Protected Area (MPA) identification (not all EBSAs should be MPAs, but all MPAs should be EBSAs).
- Not for the protection of an exploited fish stock.
- One of the "pillars" of ecosystem-based management.

Objectives

The objectives for the Bay of Fundy in this report are:

- To compare previous criteria used (Buzeta et al. 2003a) with the new EBSA criteria (DFO 2004).
- To compare the results of the previous evaluation of areas with those obtained for EBSA.
- To identify a list of EBSAs for the Bay of Fundy and approaches.
- To review sites in the Quoddy Region.
- To scientifically rationalize the basis of the significance for the West Isles (Head Harbour) area and The Passages, southwest New Brunswick.
- To provide science-based recommendations to Fisheries and Oceans managers on Bay of Fundy EBSAs.

II. METHODS

2003 Evaluations

An initiative to identify significant[1] areas in the Bay of Fundy, as part of preliminary requirements for integrated management, identified a subset of marine and coastal areas as significant (Appendix 1 & 2). Information for this evaluation was gathered from the scientific literature, or from scientists, experts, and community members with local experiential knowledge, through personal communications and questionnaires, and from workshop participants. In the course of the data gathering stage in 2001-2002, there were three workshops held, as well as personal interviews and submitted questionnaires, all requesting information regarding significant sites (Buzeta et al. 2003a).

Generally, the information summarized did not include resource assessment data already documented as part of the DFO Regional Advisory Process for each commercial species. The search for information was therefore on areas of general ecological importance, although it did include habitat of both commercial and non-commercial species, and areas critical to certain life stages (e.g. juveniles) or life processes (e.g. spawning). Information gathered therefore included evaluations of an area's significance as related to: critical/significant habitat for a particular species; importance to a geographically rare, threatened or endangered species; a biological/ecological characteristic of importance to a life cycle stage of a species (e.g. spawning, feeding aggregations, migratory path); and high biodiversity.

[1] *Significant areas criteria used in 2003: areas of importance to endangered/threatened species; of high productivity/resources; spawning, larval, nursery, or staging; of high biodiversity; of educational, research/monitoring importance; recommended for protection.*

Criteria for assessment of an area's significance at that time were based on those established for Marine Protected Areas (Canada's Oceans Act); IUCN protection and management of marine resources (International Union for the Conservation of Nature 1988); diversity or richness of habitats and/or communities (Gubbay 1995); naturalness (lack of disturbance or degradation); community values (cultural, economic, research, education); and recommendations for protection.

2006 Panel of Experts (PE 2006)

Discussions with six scientists in 2006 looked at the "transferability" of the information reported in Buzeta et al. (2003a) to the new EBSA criteria, and re-evaluated the list of potential EBSAs in view of the new criteria. The PE 2006 consisted of:

Peter Larsen, Ph. D. Bigelow Laboratory, West Boothbay Harbor, Maine. Senior Research Scientist. Expertise is coastal ecology, ecosystem modelling, Quoddy history, Quoddy assessment reports in the 1970s.

Blythe Chang, St. Andrews Biological Station, St. Andrews, NB. Biologist. Expertise in aquaculture, industry, history of research.

Peter Lawton, Ph. D. St. Andrews Biological Station, St. Andrews, NB. Research Scientist, Director of The Centre for Marine Biodiversity. Expertise on habitat impacts, habitat classification, benthic surveys, extensive field experience in Bay of Fundy.

Andrew Cooper, Ph. D. St. Andrews Biological Station, St. Andrews, NB. Research Scientist. Expertise in biodiversity, DFO policy.

John C. Roff, Ph. D. Environmental Sciences, Acadia University, Wolfville, NS. Environmental Science Canada Research Chair Tier 1. Expertise in ecology, biodiversity, ecosystem functions and processes.

Michael Owen, Ph. D. University of Western Ontario, London, ON. Professor Emeritus (Biology). Expertise in marine biology, ecology, extensive field experience in teaching and research in the Quoddy Region.

Arthur A. MacKay, St. Croix Ecosystem Project, St. Stephen, NB. Director. Expertise in ecology, species identification, benthic surveys, extensive field experience in the Quoddy region, NB shore, Grand Manan, and Brier Island.

Present Evaluations

For the present report, information previously gathered (Buzeta et al. 2003a) was used, and no new input was sought. Methods were compared and presented in Table 2.

The main EBSA criteria were applied: uniqueness, aggregation, and fitness consequences, as described in DFO (2004). The secondary dimensions, naturalness and resilience, were not commonly applied, as generally, the PE 2006 were not united on how to evaluate these secondary criteria.

The information in Buzeta et al. (2003a) was validated in 2006 to ensure it was still current, and that it could be applied to EBSA. One-on-one discussions with the scientists of the PE 2006 helped with this evaluation, as they looked at the "transferability" of the information to the new EBSA criteria, reviewed/verified the list of potential EBSA, and interpreted statistical results. Additionally, where data availability permitted, mapping or multivariate analyses evaluated the scientific basis for the EBSAs identified (Appendix 3). The final step of the review process for methodology and EBSAs in the Quoddy Region was to hold a workshop (Appendix 4).

Comparison of criteria

Recommendations by the PE 2006 provided guidance in evaluating the overlap of criteria used in Buzeta et al. (2003a), with that of EBSA criteria (Table 3). These experts also identified overlap within the EBSA criteria themselves. For example, an area may have unique habitat features not commonly found in other areas, and these features make it attractive to aggregations of organisms. In turn, there may be a fitness consequence for these organisms if those features were degraded.

Information used for assessments

Three types of information were identified and summarized: scientific surveys and analyses; scientific ecological knowledge; and traditional/local knowledge, often grouped as experiential knowledge.

Data considered for each area varied. Generally, it included information summarized in Buzeta et al. (2003a), as well as site specific analyses:

- Scientific references obtained through literature searches, workshops, personal interviews, and written submissions
- Scientific experiential knowledge provided by PE 2006.
- Hydrographic data (e.g. temperature, salinity, chlorophyll *a*, Secchi disk depth), structural data (e.g. geomorphology, multibeam), oceanography (e.g. upwelling areas) was available for some of the areas reviewed in detail.
- Species distributions and species richness were available from DFO data and MacKay et al. (1978a-c, 1979a-c).
- Statistical analyses to validate the persistence of species richness as correlated to persistent environmental features, summarized in Appendix 3 (Buzeta 2007, unpublished).

The results of the assessment are presented in the format based on that of Clarke and Jamieson (2006).

Evaluation according to EBSA criteria

This section provides the assessment for the area. Attributes for each area are summarized in point form, and the area is either recommended/identified as an EBSA, or recommendations are listed for future studies to assist with the assessment.

Management Considerations

The draft boundaries for each site were drawn to facilitate the review purpose. Size optimization to define the boundaries of the EBSAs would be achieved in consultation with scientists, managers and stakeholders.

A list of issues and management recommendations are presented, gathered during the 2001 workshops and consultations (Buzeta et al. 2003a), obtained from the scientific literature, and from the PE 2006. Wherever possible, a starting point for setting ecosystem objectives for each EBSA is suggested, based on DFO's National Ecosystem Objectives (EOs) and their application to coastal areas (Singh and Buzeta 2007). National Ecosystem Objectives for ecosystem-based management were defined by the DFO to be: productivity, habitat, and biodiversity (Jamieson et al. 2001). The application of EOs to coastal areas takes into consideration existing and new and unforeseen activities in order to achieve coastal conservation objectives and make a significant contribution to the sustainability of the offshore and larger ecosystem (Singh and Buzeta 2007).

III. ASSESSMENT

A comparison of methods used for the identification of significant areas in the Bay of Fundy (Buzeta et al. 2003a) and for identification of EBSAs (DFO 2004) are presented in Table 2 below.

Table 2. Comparison of methods for the identification of Bay of Fundy significant areas.

Significant Areas Report (Buzeta et al. 2003a)	EBSAs (this report)
Literature review	Updated reference material
Analyses: Mapping	Analyses: Mapping, multivariate analyses
Workshops/consultations: Saint John NB, Sackville NB, Wolfville NS, written submissions (Scientists, field Biologists, local experts)	1. PE 2006: Eight scientists compare criteria, review sites 2. Identified features/factors that substantiate significance of sites 3. Reviewed findings with PE 2006 4. Workshop discussion 2008

The comparison of criteria used for identification of significant areas in the Bay of Fundy (Buzeta et al. 2003a) and criteria used for identification of EBSAs (DFO 2004) are presented in Table 3 below.

Table 3. Comparison of criteria used for identification of Bay of Fundy significant areas. Table represents a summary of workshop discussions (Appendix 4.3) showing the extent to which the group achieved consensus, with the fraction indicating the number of breakout discussion groups out of a total of three that were in agreement (1/3, 2/3, 3/3).

2003 Significant Areas Report (Buzeta et al. 2003a)	EBSA (DFO 2004)		
	Uniqueness	Aggregation	Fitness
Endangered species	3/3	3/3	3/3
Cultural/economic importance	2/3	2/3	1/3
Ecological significance	3/3	3/3	3/3
Spawning/nursery/staging areas	3/3	3/3	3/3
High productivity	2/3	3/3	3/3
High biodiversity	2/3	3/3	2/3
Education/research/ monitoring	2/3	1/3	1/3
Recommended for protection	1/3	1/3	1/3

The research/education criteria, recommendations for protection criteria, and cultural importance criteria used in 2003 had no obvious overlap with DFO's EBSA criteria. Below are the recommendations from the PE 2006 that provided guidance in evaluating whether evidence for the non-overlapping criteria (i.e. research/education, recommendations for protection, culture/economic importance) was evidence for any of the EBSA criteria:

- Research/education - look at evidence of why an area becomes the focus of studies and public education:
    - The aggregation of species in a small geographic area makes it practical for designing field studies.
    - Unique benthic assemblages and aggregation of oceanographic features present opportunities for ecological studies within a small geographic area.

- Recommendations for protection - investigate the reasons why an area has been the focus of recommendations for protection, especially if this is the case more than once for the same area:
    - Does the area contain some unique attributes (e.g. high biodiversity)?
    - Is this the case for the entire area, or for many of its components? The large number of components within an area may need protection, and as a package it becomes a high priority.

- Cultural and economic significance - often this is related to the productivity and aggregation of resources that have resulted in thriving coastal communities. Considerations are:
    - Why has the area been the focus of coastal development and of marine activities?
    - Historically, were the settlements in the area because of rich resources?
    - Culturally, are there significant ties to the area because of the rich resources that enabled coastal communities to thrive?
    - Today, are there many activities (e.g. fishing, aquaculture, rockweed harvesting) that the area supports? Why is that? Is it the environmental conditions, is it the productivity?
    - Is the underlying significance to the tourism industry due to aggregation of species (e.g. benthic species richness, aggregations of seabirds, fish, seals, porpoise and whales), that have lead to the development of the ecotourism industry (e.g. kayaking, SCUBA diving, fishing, and whale, seal, and bird watching tours)?

Significant[1] areas reported in Buzeta et al. (2003a)

Sites to be re-assessed for the Bay of Fundy are listed in Appendix 1, and shown in Appendix 2. Sites noted as significant[1] in 2003 exhibiting at least six, or all seven, of the criteria used at that time were:

- West Isles
- The Passages
- Brier Island

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[1] *Significant areas criteria used in 2003: areas of importance to endangered/threatened species; of high productivity/resources; spawning, larval, nursery, or staging; of high biodiversity; of educational, research/monitoring importance; recommended for protection*

Of the above, the first two sites, West Isles (Head Harbour), and The Passages, were re-assessed in this document.

III.A. ASSESSMENT OF THE QUODDY REGION AND ITS COMPONENTS

There are many definitions of the boundaries for the Quoddy Region, but generally it includes the area shown in Fig. 1. The Quoddy Region is at the southwest mouth of the Bay of Fundy and includes: The St. Croix Estuary, Passamaquoddy Bay, Deer Island, The Passages (Big Letete and Little Letete), Western Passage, West Isles Archipelago (a.k.a. Head Harbour area), Campobello Island, The Wolves, occasionally the waters out to the coast of Grand Manan, as well as Cobscook Bay in Maine (Thomas 1983; Buzeta et al. 2003a; Larsen 2004).

While Cobscook Bay is in Maine, it is discussed as part of the larger Quoddy Region ecosystem, as it has many similarities to the Canadian components.

Chevrier (1959) divided the Quoddy Region into two subcomponents based on oceanography:

- The Inner Quoddy Region that includes Passamaquoddy Bay and the St. Croix Estuary,
- The Outer Quoddy Region which is bounded by The Passages (Big Letete, Little Letete and Western Passage), Grand Manan, and northward to Point Lepreau, including Deer Island, Campobello Island, numerous ledges, and the 40 plus small islands (West Isles) also known as the Head Harbour Passage area.

Larsen (2004) provides an excellent historical backdrop to the significance of the Quoddy Region. The recognition of the area's richness began with Aboriginal peoples more than 10,000 yr ago, followed by French settlers in the 1600s and the general observations of Champlain in 1604. Scientific observations began in the late 1800s, most notably with the observations of W. Stimpson on marine invertebrates. Since then there have been numerous references to the Quoddy Region's abundance of resources and ecological significance. In many of the older reference materials it is difficult to pinpoint the exact locations within the Region. For this reason, there is considerable redundancy in reference material when it is applied to the large Quoddy Region as well as to smaller areas being reviewed within it (e.g. Head Harbour area, The Passages). Research in this area formally began in 1908 with the establishment of the St. Andrews Biological Station (Hart 1958; Chang 1999).

For the purposes of appropriate management of the Quoddy Region, we review it as a whole Region first, and then review components identified within.

Quoddy Region – Evaluation according to EBSA criteria

Through its geographic components (Fig. 1a), inclusive of Cobscook Bay, ME, the Quoddy Region is recognized as a significant ecosystem within Bay of Fundy-Gulf of Maine. However, the Region may be too large to be effectively managed as an

EBSA, and therefore, its components, the smaller areas within, have also been evaluated.

Uniqueness

1. From a geological time perspective, scientists suggest that the Quoddy Region is ecologically unique as a result of recent and rapid geological evolution. It is these rapid changes in geology and oceanography that have occurred since the last glaciation, that have resulted in the present distribution and richness of biota. Changes in sea level through geological time allowed the spread of warm water species into the region. In time, the tidal range continued to increase in this area, breaking down the thermal stratification, resulting in tidal mixing. This resulted in very cold waters in the summer, but relatively mild temperatures in the winter (Larsen 2004).

2. From a contemporary perspective, scientists suggest that the Quoddy Region is ecologically unique and zoogeographically complex as a result of the large tidal amplitudes, combined with the Region's benthic topography and the effect that the many islands have on the tidal currents (Trites and Garrett 1983; F. Page, DFO, Biological Station, St. Andrews, NB, E5B 2L9, pers. comm.).

3. In summary, the high biodiversity and unusual ecological conditions which support it occur due to extreme tidal mixing and hydrographic conditions as a result of geological history, and these conditions are not thought to be reproduced elsewhere (Larsen 2004).

4. The assemblages of marine biota in the Quoddy Region are a reflection of a summer cold-water pocket in a relatively small area, when compared to the inner Bay of Fundy, or the rest of Gulf of Maine and Scotian Shelf. Due to the temperature regimes, cold water species (subarctic) are able to reproduce in winter and spring, and warmer water species move in during the summer (F. Page, DFO, Biological Station, St. Andrews, NB, E5B 2L9, pers. comm; Larsen 2004).

5. This area has more hard substrate than generally found in other areas of the Bay of Fundy, and Brilliant (2001) suggests it has significant aspects that need to be protected.

Aggregation

1. The Quoddy Region has been proposed as a Marine Protected Area because of the feeding aggregations of marine mammals which it supports. Reasons listed are the presence of the endangered North Atlantic right whale, a transient resident of the Quoddy Region; the harbour porpoise, currently listed as Threatened in this Region, and several other species of whales found aggregated in this Region during late summer and early fall (IMMA 2001).

2. Twenty-one Canadian and USA scientists convened in 1999 by the Marine Conservation Biology Institute (MCBI), identified the Quoddy Region as one of the "highest priority areas for protection" in the Gulf of Maine, based on the hard bottom and high diversity of sessile marine invertebrates (MCBI 1999).

3. Quoddy is one of the headlands into the Bay of Fundy (the other being Brier Island), but Quoddy is believed to have the maximum number of benthic biota found (A. A. MacKay, St. Croix Estuary Project, St. Stephen, NB, Canada, E3L 2X3, pers. comm.).

Fitness consequences

1. The Quoddy Region has been identified as critical marine habitat for 1-2 year old herring (Messieh 1992).
2. The outer areas of the Region (West Isles, Campobello-Grand Manan) are critical habitat for red-necked phalaropes (*Phalaropus lobatus*) in late July to early September (Messieh 1992).
3. Quoddy is important to marine mammals as a feeding area, including the endangered North Atlantic right whale, and the harbour porpoise currently listed as Threatened.

Naturalness and Resilience

1. In an environmental risk assessment for this area as an oil terminal, this Region was quoted as having the "highest degree of environmental vulnerability, and hence, the highest environmental risk of any site on the Canadian eastern seaboard" (Yuen 1976).
2. Estimates in the event of a disaster (e.g. oil spill) suggest that contamination of much of the Quoddy Region would occur within a week (Loucks et al. 1974). This is based on tidal velocities, which vary from near 0 $cm \cdot s^{-1}$ to several 100 $cm \cdot s^{-1}$ (F. Page, DFO, Biological Station, St. Andrews, NB, E5B 2L9, pers. comm.).
3. Marine activities in the area overlap substantially, and include a variety of fisheries, aquaculture, and tourism. However, areas of rocky substrate in the nearshore had precluded many dragging/dredging operations, until recently (e.g. *Cucumaria* fishery).

Quoddy Region - Management considerations

1. The Region may be too large to be effectively managed as an EBSA. Therefore, protection of its attributes might be achieved through management of activities taking place within the smaller areas within, those components of Quoddy assessed as EBSAs.
2. It should be recognized that there are many definitions of the boundaries for the Quoddy Region, depending on the study or discussion focus.
3. Coastal southwestern New Brunswick is often seen as an aquaculture and fishing centre, and is thought to be overshadowed by the upper Bay which is recognized for its mud flats, salt marshes and large bird migration areas (Brilliant, 2001).
4. Concerns include dragging, aquaculture, and large-scale industrial development, but these are discussed as part of specific locations mentioned (i.e. The Passages, Head Harbour).

5. The Quoddy Region was suggested for a pilot study on Integrated Marine Planning (Buzeta et al. 2003b), whereby an interdisciplinary discussion group identified the Region as the larger management envelope for a smaller pilot study within. The group considered the Region to be a biological hotspot, contain a diversity of habitats and marine activities, have sufficient capacity (scientific, economic, cultural), and have a potential for Canada-USA transboundary collaborations, thereby making it a good candidate for a coastal management area.

III.B. ST.CROIX ESTUARY

The St. Croix Estuary is a true estuary, and has the mixed faunal assemblages typical of both high and low salinities (MacKay et al. 1978a).

In 1982, the State of Maine identified the St. Croix River as a Class A river for its natural, recreational, and historical significance. It was also designated a Canadian Heritage River in 1991, currently the only one in New Brunswick.

Todd's Point, a parcel of land approximately 1.3 km^2 (687 m^2 land, 647 of it being intertidal), is protected by the St. Croix Estuary Project and the NB Nature Trust, as the Whidden and Eleanor Ganong Nature Park. The nearby community considers this area a special place because of its diverse tide pools, intertidal area, and historical context.

St. Croix Estuary – Evaluation according to EBSA criteria

The information gathered at workshops (Buzeta et al. 2003a) suggests that this area is a key component of the Quoddy ecosystem, and is presently of importance to waterfowl. However, evaluation of its attributes did not provide strong evidence to list this area as an EBSA.

Fitness consequences

1. In 1982 the St. Croix Estuary was proposed as an Ecological Reserve for its significant land features, and its regional significance as a feeding and staging area for ducks, geese, shorebirds and gulls (Hunter and Associates 1982).

III.C. PASSAMAQUODDY BAY

Principle biotic groups found are molluscs, echinoderms and marine plants. Sponges and tunicates are poorly represented, most probably due to temperature and salinity fluctuations in the area, although water quality may also be a factor (MacKay et al. 1978a).

Passamaquoddy Bay – Evaluation according to EBSA criteria

Sam Orr's Pond was evaluated as a potential EBSA on the basis of (unique) atypical warmer waters, and the flora and fauna atypical to this area. Tongue Shoal was examined on the basis of species aggregations, specifically high benthic species diversity.

Review of information according to EBSA criteria for areas within Passamaquoddy Bay resulted in the conclusion that Passamaquoddy Bay, Sam Orr's Pond, and Tongue Shoal meet some of the requirements but not all of the EBSA criteria.

Uniqueness

1. Sam Orr's Pond, located on the northern shore of Passamaquoddy Bay, approximately 18 thousand km^2 in size, exhibits atypically warm waters, and the flora and fauna are atypical to this area. Temperatures in the summer are consistently above 20°C (Mortimer and Downer 1961). The pond experiences cyclical fluctuation of surface salinities, ranging from 4‰ - 30‰, and there are several days each month during which no tides enter the pond. The quahaug, *Mercenaria mercenaria,* typical of warm water areas, is native to the pond (Reid et al. 1962), and has been present in this area for over 10,000 yr, imparting to the pond a historical and traditional importance, as the quahaug was a food source for the Abenaki tribes.

Aggregation

1. Hardwood Island was recommended as an Ecological Reserve (Wein and Jones 1975) for its diverse avian population, and for the purpose of preserving this natural area for science, education, for gene pool preservation, and to provide a benchmark. At that time, it was considered to have a large and diverse avian population, with a large nesting colony of great blue herons (*Ardea herodias*), nesting ospreys, and thousands of herring gulls (*Larus argentatus*), and was an important stopover for migratory birds. The island is also home to a large and important common eider nesting colony (Diamond 2001).

2. Key areas of productivity as indicated by diversity/abundance ratings are northern Passamaquoddy Bay, St. Andrews Point, and the St. Croix Estuary (MacKay et al. 1978a). Tongue Shoal is considered to have higher than average species richness, including species not commonly found in Passamaquoddy Bay (MacKay et al. 1978a; A. A. MacKay, St. Croix Estuary Project, St. Stephen NB, E3L 2X3, pers. comm.).

Fitness consequences

1. There are several small islands in the north of Passamaquoddy Bay that are considered to be very important areas for rearing and as migration stop-overs for sea ducks, gulls, sandpipers and phalaropes (Christie 2001).

2. The areas around St. Andrews, Chamcook, Digdeguash and the Magaguadavic River were identified as Regionally Significant because they serve as feeding

and staging areas for ducks, shorebirds, eagles and osprey (*Pandion haliaetus*) (Hunter and Associates 1982).

3. Hardwood Island, approximately 14.2 ha, was identified as a breeding site for herons, gulls and common eiders (Thomas 1983).
4. Hog Island has eider and cormorant colonies (Diamond 2001).
5. Birch Cove was reported to have a significant juvenile lobster population occupying the shallow subtidal boulder/cobble habitats, and the area from McCann Head to Creighton Point, next to Dick's Island, is reported as having a lobster population characteristic of a lobster nursery area. Northern Passamaquoddy Bay (Birch Cove, Bocabec Cove, Dicks Island and Hog Island) has a higher relative abundance of lobsters than the eastern and western areas of the Bay (Lawton 1993).
6. Sam Orr's Pond has a large number of *Anguilla rostrata* elvers present (Mortimer and Downer 1961).
7. In northern Passamaquoddy Bay there are reported cod spawning locations (McKenzie 1934). However, in a report on fishermen's knowledge of spawning areas, there was no evidence that this area still persisted (Graham et al. 2002).
8. Many coastal spawning areas have been lost, but the importance of coastal areas to the life cycles of many fish is still being demonstrated. Juvenile cod were reported, to have been captured in beach seines in Passamaquoddy Bay (MacDonald et al. 1984).

Passamaquoddy Bay - Management considerations

1. Sam Orr's Pond is presently being managed as a reserve with an appropriate management plan that should provide sufficient protection. However, nearby marine activities should be monitored and managed in view of its significance. It is part of the Caughey-Taylor Nature Preserve established by the New Brunswick Nature Trust in 1999. The reserve encompasses approximately 1 km^2 of land, salt marsh, and tidal estuary. It continues to be used as a study site by many scientists and students.
2. Tongue Shoal was acknowledged as having high benthic species diversity, and therefore, there is concern that this area may be impacted by sea cucumber dragging nearby (Voutier et al. 2006; M. Strong, DFO, Biological Station, St. Andrews, NB, E5B 2L9, pers. comm.). As a precautionary measure, dragging, dredging or other activities with a potential for benthic impacts, should be restricted on Tongue shoal until further study.
3. Most areas identified within Passamaquoddy Bay involve terrestrial attributes, or avian aggregations.
4. An aquaculture site right next to Hog Island is thought to cause a disturbance to eider and cormorant colonies on the island (Diamond 2001).
5. Ecosystem objectives to be considered for Sam Orr's Pond and Tongue Shoal: biodiversity, habitat.

III.D. HEAD HARBOUR / WEST ISLES (HH/WI)

The Head Harbour area is interchangeably called West Isles, Outer Quoddy Region or Quoddy Isles. Wherever possible, the name used by the reference material has been maintained, otherwise the general term HH/WI will be used. Figure 2 identifies the location of sites mentioned in this section.

In the summer of 2001, members of the Passamaquoddy-Scoodic Tribe reflected on the spiritual importance and cultural significance of this area, and there is interest in protection measures (Akagi 2001). For thousands of years people utilized the West Isles for hunting, fishing, gathering, and for religious ceremonies. Prior to European settlement, the West Isles or "Quoddy" area was frequented by the Passamaquoddy Tribe and there are several shell midden sites as evidence, as well as recollections of porpoise hunting from canoes.

The underlying significance of this area to the tourism industry relates directly to the EBSA criteria of aggregations (i.e. benthic species richness, aggregations of seabirds, fish, seals, porpoise and whales). The rich and diverse assemblage of seabirds, marine mammals, and benthic invertebrates, have lead to the development of the ecotourism industry that includes kayaking, SCUBA diving, fishing, and whale, seal, and bird watching tours.

Head Harbour / West Isles – Evaluation according to EBSA criteria

The HH/WI area has long been recognized as unique and significant, and workshop participants once more agreed that the area is clearly and without question, a significant area. There is substantial information, and recommendations in the literature, to identify HH/WI as an EBSA.

There are several sites within HH/WI identified for specific EBSA attributes. Because of the number of interconnected sites identified within this area, it is more ecologically appropriate, and practical from a management perspective, to identify the HH/WI area as a whole. The boundaries could be based on information from the literature, as aggregated in Fig. 2.

The EBSA attributes identified are: species aggregations (invertebrate, avian, marine mammal), as well as aggregation of oceanographic features (upwellings, currents, benthic complexity); uniqueness of species assemblages, and of environmental features (range of temperature and salinity, geomorphology, benthic complexity) that provide the mechanism for species aggregations; fitness consequences associated with juvenile and rearing stages of fish, avian, and marine mammal species.

Uniqueness

Head Harbour has been historically identified as unique, making the area the focus for benthic research since 1908 (P. Larsen, Bigelow Lab, West Boothbay, ME 04575, pers. comm.). Based on benthic surveys, and the cluster of ledges, reefs and walls rich in biota, the area was short-listed as one of three areas for protection (Parks Canada/Tourism New Brunswick 1985).

1. Uniqueness results from the combination of large tides, complex benthic topography, and the tidal streams around these scattered small islands resulting in a diversity of current velocities, eddies and gyres. This causes many shear zones, upwellings, and convergences that force plankton to the surface in concentrated patches (F. Page, DFO, Biological Station, St. Andrews, NB, E5B 2L9, pers. comm.).

2. Rocky substrates, mostly rock outcrop or boulders except for sheltered areas where sand and mud predominate, are commonly found in this area. The benthic complexity of the topography in this area is in sharp contrast to that of Passamaquoddy Bay (Fig. 4). The rocky substrate forms walls and overhangs that provide a complex habitat. Large macro-invertebrates, such as anemones, tunicates, and sponges, abound on these surfaces.

3. The presence of two of the larger ascidian (tunicate) species, *Halocynthia pyriformis*, dominant above 20 m, and *Boltenia ovifera* dominant at 10-20 m and 80-90 m, indicate physical conditions related to hard substrate, and moderate to strong currents, not generally seen in other areas (Hatfield et al. 1992).

4. Ecologically unique because it generally harbours the highest levels of diversity of benthic macro-invertebrates in the Bay of Fundy. A comparison of invertebrate species richness showed a gradient from southern Maine to Head Harbour, and from St. Croix Estuary to HH/WI, with highest species richness found in HH/WI (Larsen 1979; MacKay et al. 1978c; Buzeta et al. 2007; Appendix 3).

5. Lawton (1992, 1993) reported that these highly diverse benthic communities may be of conservation significance and should be further evaluated, and that they do not appear to be generally distributed throughout the region, making the HH/WI area unique.

6. Statistical analyses shown in Appendix 3, of benthic survey data (MacKay et al. 1978a-c, 1979a-c), identified the West Isles as having higher than average species richness. Further, the assemblages were significantly correlated to environmental factors in the area (temperature, salinity, chlorophyll, turbidity, substrate, geomorphology, benthic complexity), leading to the conclusion that it is these persistent features, as well as additional factors being tested (current speed, dispersal and colonization processes), that provide suitable habitat for more species. Specifically, regardless of annual fluctuations in abundances of individual organisms, the characteristics of the HH/WI are conducive to higher species richness.

7. White Horse Island is the only breeding site in the Bay of Fundy of northern gannet; whose first nesting since 1880 was observed in 1990 (S. Corrigan, DFO, Truro, NS, B2N 5A9, pers. comm.).

8. HH/WI Archipelago and The Passages have been identified as significant and considered to be ecologically unique, because of the high diversity of benthic fauna, marine mammals, and avifauna (Buzeta et al. 2003a; Gaskin et al. 1985; Larsen 1979, 2004).

Aggregation

Significance of this area specific to species aggregations/species richness has been reported in publications, during workshops, and through written submissions and personal observations:

1. The West Isles and passages were identified as regionally significant and proposed as an Ecological Reserve, based on a very high diversity and abundance of marine invertebrates, fish, birds and mammals (Hunter and Associates 1982).
2. The presence of regionally significant species (e.g. redfish, juvenile cod, pollock, whales) impart a high importance rating to this area (Burt 1997).
3. The area has higher species diversity (Casco and Simpson Islands), and Casco Island has an "impressive array of marine life" (Lawton 1992, 1993).
4. The West Isles was identified as one of the "highest priority areas for protection" in the Bay of Fundy, because of its high diversity of benthic fauna (MCBI 1999).
5. The islands exhibit interesting and diverse benthic faunal assemblages/aggregations (Thomas 1983). Compilations of species lists suggest a rough estimate of 1,500 benthic species may occur in Passamaquoddy – West Isles – Cobscook area (350 km^2) (Larsen 2004).
6. Species diversity surveys indicated that some of the areas within HH/WI have a higher number of sessile benthic species and generally have the highest levels of diversity of benthic macro-invertebrates in the Bay of Fundy (Parks Canada/Tourism New Brunswick 1985).
7. High species abundance/diversity were recorded among the islands and ledges of the West Isles (e.g. Hardwood, Adams, Simpson's, Sandy, Spruce, Tinker, and Black Rock), within Head Harbour, and off Deer Island Point (MacKay et al. 1978c).
8. Increased numbers of upright (e.g. *Haliclona oculata*) and massive (e.g. *Myxilla* spp.) sponges in the area were significantly correlated to vertical rock slope, boulder sides, and cliff sides (Ginn et al. 2000), with large sponges commonly found at the bottom of the ledges (Thomas 1983).
9. Nubble Island exhibits a *Edwardsia-Corymorpha-Coryphella* community found in shallow waters. The geographically rare anemone *Edwardsia elegans* is present at this site (MacKay et al. 1978c; M-I. Buzeta and M. Strong, St. Andrews Biological Station, St. Andrews, NB, E2L 2L9, dive log 2001). Boulders around Nubble support brachiopod communities, and the tunicates *Halocynthia pyriformis* and *Boltenia ovifera* are abundant.
10. Simpson Island - high densities of the anemone *Gonactinia* were found only at this site. The brachiopod *Terebratulina septentrionalis* was found consistently on its shaded cliff faces, and the highly cleaved rocks provided crevices for attachment of *Myxicola infundibulum*, which was most commonly found at this site. The soft coral *Gersemia* is abundant at shallow depths along the length of the wall (Logan et al. 1984).

11. A very diverse and abundant community of sessile organisms is found along the eastern side of Casco Island, due to the presence of vertical rock walls and high currents (Logan et al. 1984). Casco, Spruce, and White Islands - the steeply inclined rock faces and boulders are subject to high tidal ranges flowing through the constricted passages, resulting in high tidal current velocities, sufficient to prevent significant sedimentation. Marine cliff faces show an abundance of bryozoans, anemones, sponges and brachiopods, while overhangs are dominated by *Terebratulina septentrionalis*. The deeper zones studied (18 m) showed the greatest species richness including sponges, hydroids, anemones, brachiopods, and tunicates. The distinctive sublittoral hard substrate communities are that of *Terebratulina septentrionalis* and that of the crustose coralline algae, *Lithothamnion* sp. (Logan et al. 1984).

12. Simpsons Island - rich in benthic finfish, including small aggregations of winter flounder. Spot dives (M. Strong and M-I. Buzeta, St. Andrews Biological Station, St. Andrews, NB, E2L 2L9, video log and dive log 2001) verified the presence of juvenile cod, and juvenile and spawning (video log, not verified) redfish *Sebastes fasciatus kellyi* (Scott and Scott 1988; M. Strong and M-I. Buzeta, St. Andrews Biological Station, St. Andrews, NB, E2L 2L9, video log and dive log 2001) in rock crevices and aggregated at a large cave.

13. Mowatt, Sandy, and Casco Islands - aggregations of groundfish species (juvenile cod, redfish, cunner) (M. Strong and M-I. Buzeta, St. Andrews Biological Station, St. Andrews, NB, E2L 2L9, video log and dive log 2001).

14. Sandy Island – within a very small area, this site exhibits both physical and biological diversity (i.e. aggregation of features, habitats, and species). A transect running northeast to southwest direction includes a range of substrates (sandy beach, rocky intertidal reef, depositional area, cobble and boulder areas, shelving reefs with crevices and overhangs exposed to high currents) (M-I. Buzeta, St. Andrews Biological Station, St. Andrews, NB, E2L 2L9, dive log 2002). Along with these physical changes are the characteristic species associations. A herring weir is located next to shore, and the soft sediment around it is populated with the large burrowing anemone, *Cerianthus borealis*. Sandy patches are also found here, populated with large numbers of the solitary hydroid *Corymorpha pendula*, and the rarely seen burrowing cucumber *Sclerodactyla* spp. Epibenthic macroinvertebrates on sand also include the small burrowing anemone *Edwardsia elegans*, and the nudibranch *Aeolidia papillosa* (MacKay et al. 1978c; M-I. Buzeta, St. Andrews Biological Station, St. Andrews, NB, E2L 2L9, video log 2001). Soft corals *Gersemia rubiformis*, commonly called strawberry grounds, are found abundantly in the shallower areas of the reef. Fishermen recognize these "strawberry grounds" as good for lobster fishing, and their value as a component of benthic habitats for other species including lobsters is recognized by scientists. The tunicate *Halocynthia pyriformis* is common in the cobble areas. The species assemblage quickly changes near the end of the reef. Here, species characteristic of a hard substrate and high tidal velocity abound: large tunicates *H. pyriformis* and *Boltenia ovifera*, and massive sponges. Habitat complexity is high, sponges providing further biogenic habitat for small isopods and starfish (Caddy and

Carter 1984). The underside of rock faces are covered with the lampshell *Terebratulina septentrionalis*, which characterize this habitat type (Logan and Noble 1971; Logan et al. 1983; Noble et al. 1976).

15. Subtidal transects of the Head Harbour area showed a profile that drops precipitously to 13 m. Aggregations of hydroids occur here, specifically at Casco Island (Logan et al. 1984). The community is described by Logan (1988) as lacking coralline algae, and being abundant in *Tubularia* hydroids, the anemone *Tealia felina*, and the horse mussel, *Modiolus modiolus*. The soft coral *Gersemia rubiformis* is found in large numbers on the southwest rocky wall (M-I. Buzeta, St. Andrews Biological Station, St. Andrews, NB, E2L 2L9, video log 2001).

16. Head Harbour Passage, west to Spectacle Island and Sandy Island, and out to White Horse Island, represents the core areas important for harbour porpoise, finback whales and marine bird aggregations (MacKay et al. 1978c). The Gulf of Maine report on habitat identification of species of anthropogenic importance in the Quoddy region indicates that high abundances of harbour porpoise (*Phocoena phocoena)* occur in the area north of Head Harbour, while medium abundances occur east of Campobello Island (Burt 1997).

17. The many ledges in the West Isles area are known seal haulouts (CCRM 1999; Terhune 2001; Parks Canada/Tourism New Brunswick 1985; Buzeta et al. 2003a).

There are several references suggesting the mechanisms for the diverse communities found in the HH/WI area as follows:

18. High diversity and abundance of invertebrates was found to be associated with the high currents in the area, and with suitable habitats. This gives rise to high numbers of species: 836 invertebrates, 96 fish, 70 birds, 20 mammals, and 223 plants (Hardie 1979).

19. Upwelling areas and other oceanographic features bring deep living nekton close to the surface and result in concentrations of organisms at higher trophic levels (fish, seabirds, whales) (Smith et al. 1984; PE 2006).

20. There are visible, but highly mobile, aggregations of species that form part of a food chain that includes copepods, euphausiids, mackerel, herring, squid, common and Arctic terns, herring gulls and Bonaparte's gulls, northern (red-necked) phalaropes, finback, humpback, and minke whales, and harbour porpoise (Smith et al. 1984; Gaskin 1977). These aggregations move according to tidal cycles, especially in the areas between the West Isles, Head Harbour Passage, White Horse Island and The Wolves (Gaskin and Smith 1979).

21. There is a gradient in hydrographic conditions from estuarine to oceanic from St. Croix Estuary out to the midbay, with the West Isles area having more stable temperature and salinity, which is significantly correlated with higher number of benthic species (Buzeta et al. 2007; Appendix 3). Species richness decreases inland with estuarine conditions in St. Croix Estuary and

Passamaquoddy Bay, and midbay in the Bay of Fundy where conditions become more oceanic.

22. The availability of hard substrate, along with complex bottom topography (Fig. 4 and Section 6) provides more habitat for more sessile invertebrates. Thus, the high level of benthic species diversity is also a result of availability of substrate, higher complexity, and the distribution of this substrate within a matrix of soft sediments (Hubbell 2001; Greenlaw et al. 2007; Buzeta et al. 2007; Appendix 3).

Fitness consequences

Many coastal spawning areas have been lost, but the importance of coastal areas to the life cycles of many fish is still being demonstrated. Local knowledge, surveys, and video observations, suggest that the HH/WI area may contribute to the life cycle of a wide number of species.

1. The area is considered one of the principal areas for enhancement of Fundy waters as they pass from Saint John to the West Isles, and an area where zooplankton depletion or enrichment occurs (Hunter and Associates 1982).
2. The Deer Island Archipelago (West Isles) is documented as an Environmentally Significant Area (ESAs) (NBDELG ESA database; Atlantic Canada Conservation Data Centre), and an important avifauna area (Parks Canada/Tourism New Brunswick 1985; Diamond 2001; K. Davidson, CWS, Sackville, NB, E4L 1G6, pers. comm.). Upwelled plankton, such as the euphausiid *Thyanoessa* sp., and the copepod *Calanus finmarchicus*, attracts large numbers of Bonaparte's gulls *Larus philadelphia*, red-necked phalaropes *Phalaropus lobatus*, and herring *Clupea harengus* from July to September.
3. The waters and islands of Head Harbour Passage are of major Canadian significance because of high concentrations of migrating, feeding and breeding birds (phalaropes, ducks, shorebirds) (Hunter and Associates 1982). The HH/WI area alone has been known to support over 50% of the Canadian population of red-necked phalaropes (Lotze and Milewski 2002).
4. It is considered an important staging area for red-necked phalaropes, and may possibly host the entire breeding population of eastern Canada, Greenland and Iceland (Duncan 1996). Phalaropes prey on the copepod *Calanus finmarchicus*, and therefore move according to the tides in/out the Quoddy Region. Red-necked phalaropes have been declining during migration at their traditional sites (e.g. around Deer Island). The most likely cause of this decline is the severe reduction in copepod abundance since 1990. The cause of the copepod decline is unclear, but may be related to the increase in sea temperatures over the last 100 yr (Brown et al. 2005; PE 2006).
5. Sandy Island is an important area for common eider *Somateria mollissima* nesting, and on nearby Tinker Island there is a cormorant *Phalacrocorax auritus* nesting site (Buzeta et al. 2003a).
6. White Horse Island is an important nesting area for guillemots *Cepphus grylle*, a large colony of double-crested cormorants *Phalacrocorax auritus*, and possibly

the northern gannet *Morus bassanus*. It is a newly colonized site of breeding black-legged kittiwakes *Rissa tridactyla*. There are sightings of over a dozen mature and immature puffins *Fratercula arctica*, and a nesting pair of puffins, and of gannets were photo-confirmed in 1999. Sightings of parasitic jaegers *Stercorarius parasiticus* were also photo-confirmed. The island itself, and the surrounding waters, are critical as nesting and feeding habitat (S. Corrigan, DFO, Truro, NS, B2N 5A9, pers. comm.; M-I Buzeta, DFO, Biological Station, St. Andrews, NB, E5B 2L9, pers. comm.; Diamond 2001).

7. The large sponge species found in this area, such as *Pellina and Halichondria*, add complexity to the habitat surface, which provides refuge for lobster, crabs, juvenile cod, cunner, and tautogs. Sponge reefs are known to form bio-herms and observations suggest that they provide refuge for shrimp and small fish, and therefore, there are fitness consequences associated with their presence (Conway 1999, Stocker and Pringle 2000).

8. Moderate to high lobster population (e.g. Bean Ledges) are found in some areas. Berried lobsters are present during the summer months, widely dispersed among the rock wall, ledge, and boulder habitats fringing the islands (Lawton 1992, 1993).

9. A large number of stalked ascidians *Boltenia ovifera* are found at Mowatt Island (Hatfield et al. 1992), providing refuge for several species of juvenile fish (cod, pollock), and cunner *Tautogolabrus adspersus*. Spot dives verified large numbers of juvenile cod *Gadus morhua* found amongst the refuge provided by the complex rocky habitat, and the attached stalked ascidians and sponges (M. Strong and M-I. Buzeta, St. Andrews Biological Station, St. Andrews, NB, E2L 2L9, video log and dive log 1999-2001).

   a. The presence of juvenile cod, juvenile redfish, spawning redfish, and Atlantic wolffish pairs, at Simpson, Mowatt, Sandy, and Casco Islands, and at Deer Island Point, is known locally and was verified during spot dives (M. Strong and M-I. Buzeta, St. Andrews Biological Station, St. Andrews, NB, E2L 2L9, video log and dive log 1999-2001). Their presence makes these areas critical habitat, contributing to the fitness of the local and overall populations.

   b. Juvenile cod *Gadus morhua* were commonly found among the rock crevices and stalked tunicates.

   c. The shallow-water inshore form of the redfish *Sebastes fasciatus kellyi* (Scott and Scott 1988) was recorded in rock crevices and caves, overhangs, and rock fissures. Generally, juvenile cod are seen associated with species that provide refuge (*Boltenia ovifera)*. Specifically, redfish juveniles and large ripe (DFO maturity stage designation) females were videotaped inside and near a large cave at 20 m depth at Simpson's Island.

   d. Spawning lumpfish *Cyclopterus lumpus* have been recorded and photographed in the West Isles (Simpson's Island), including a male guarding the egg nest. Spawning is known to occur in shallow water on rocky substrates (Daborn and Gregory 1983). Males remain to guard the nests for

6-8 wk until the young hatch, while females presumably swim out into deeper water.

e. There are pairs of the wolffish *Anarhichas lupus* at all three of these sites, as well as White Island, that have been recorded (TEK, divers' logbooks) for many years in crevices/caves (Fig. 5). Sexually mature fish are thought to move inshore to shallow waters to spawn, but adult Atlantic wolffish are relatively sedentary and may remain at these sites for many years. Eggs are deposited on the bottom and are guarded by the male. Larvae remain close to the site of hatching and there is limited adult migration. Because of its declining population, 87% decline rate over two-three generations, the Atlantic wolffish meets IUCN criteria of Critically Endangered (O'Dea and Haedrich 2002). However, due to its widespread distribution, it is presently listed as a species of Special Concern by COSEWIC (January 2007).

f. At Deer Island Point (Fig. 5), there are several wolffish pairs consistently seen by divers (M. Murphy, Quispamsis, NB, E2E 5B9, pers. comm.).

g. Several harbour seal (adults and pups) haulout sites occur in HH/WI, including Sandy Island ledges (Terhune 2001, unpublished data).

h. Significant numbers of female harbour porpoise and calves occur in the Simpson Island area (Smith et al.1984), and the HH/WI area appears to be the center of the Harbour Porpoise feeding and aggregation area (SENES Consultants Ltd. 2006).

i. Among the Head Harbour areas there are records by the whale-watching industry of right whale sightings, and several published and current records of humpback, finback, and harbour porpoise mother and calf sightings.

j. White Island, and the sill close to the tip of Campobello Island, seem to be critical features in the feeding areas for finback whales, as shown in tracks recorded (Gaskin and Smith 1979).

Naturalness and resilience

1. This area has been described as pristine and natural (CCNB 2004; Save Passamaquoddy Bay 2007). However, a systematic assessment of this attribute has not been made.
2. There are a large number of marine activities in the area, including fishing, aquaculture, and rockweed harvesting.
3. Until recently, dragging occurred mostly in the deeper, soft sediments for scallops. More recently sea cucumber dragging is beginning to expand into this area (Fig. 3) (Voutier at al. 2006).

Head Harbour / West Isles - Management considerations

The HH/WI area has long been recognized as unique and significant, and workshop participants agreed that the area is clearly and without question, a significant area.

In many cases, this conclusion includes recognition as a priority for protection based on the following:

1. Identification as a Natural Area of Canadian Significance and proposed as a National Marine Park (Parks Canada/Tourism New Brunswick 1985) (Appendix 1). Specifically identified were the subtidal areas around Adams, Spruce and Casco Islands as proposed underwater eco-trails, due to the high diversity of benthic invertebrates in these sites.
2. It being proposed as an Ecological Reserve in a report commissioned by the Province of New Brunswick (Hunter and Associates 1982).
3. The interest by members of the Passamaquoddy-Scoodic Tribe in its protection (Chief Akagi, Passamaquoddy-Scoodic Tribe, St. Andrews, NB, 2001).
4. It being suggested as a pilot study on Integrated Marine Planning by an interdisciplinary discussion group, for its diversity of habitats and marine activities (a biological hotspot), sufficient capacity, and potential for Canada-USA transboundary collaborations (Buzeta et al. 2003b).
5. The Quoddy Region, the area within a line drawn from Point Lepreau on the north shore of the Bay of Fundy, south to the Grand Manan Archipelago and west to the Maine shore (inclusive of HH/WI), being considered one of few a marine regions of such importance that it warrants special attention, and a marine oasis of international significance (CCNB 2004).
6. A recent petition sponsored by St. Croix Estuary Project Inc, was issued for DFO to *Declare Head Harbour Passage and West Isles an Emergency Marine Protected Area*. The premise is that this will prevent unsuitable development until a proper management plan can be established that will protect this unique and vital habitat. Traditional fisheries, aquaculture and tourism would all be grandfathered in a marine protected area, while large new developments such as LNG terminals would not be, until a future plan is decided on and agreed upon by the communities involved (Save Passamaquoddy Bay 2007, MacKay 2007, Quoddy Tides 2007).
7. Near-shore, benthic communities which are good indicators of disturbance as their relative lack of mobility makes them more likely to be affected by human activities, and the near-shore benthic organisms involved in benthic-pelagic coupling that provide a link for contamination of higher trophic levels (Smith et al. 1988). As such, the reefs and ledges around the West Isles still exhibit this quality and are useful monitoring and baseline study areas, if left unperturbed.
8. Barnes, Nubble and Mowatt Islands being under the protection of the Nature Conservancy of Canada.
9. Identified in 1999 as one of the "highest priority areas for protection" by a group of 21 Canadian and USA scientists convened by the Marine Conservation Biology Institute. The West Isles was one of the areas identified in the Bay of Fundy, because of its high diversity of benthic fauna.
10. Marine Protected Areas discussion session at Coastal Zone Canada 2000 (Chopin and Wells 2001), where participants concluded that there is sufficient

information out there for "some" cases to be protected. An example given was Head Harbour, because of the marine mammal aggregations and migration paths for many species of seabirds (Gaskin and Smith 1979).

11. Recommendation from Logan (2001) who suggests that the Head Harbour area should be protected. There is a tremendous volume of water that passes through, and the benthic biota are diverse and abundant.

12. Recommendation by Diamond (2001) that White Horse Island receive protected status based on its importance to migratory birds.

13. Recommendation for protection of this area known as a stop-over for migratory red-necked phalaropes. This is seen as a requirement if their dwindling populations increase (Brown et al. 2005).

14. Need for increased awareness amongst users about the significance of the area to migratory birds. There are recommendations that rockweed harvesting be limited and salmon farming be restricted to areas that are not as sensitive as HH/WI (Diamond 2001).

15. Concerns expressed for this area include siltation, eutrophication, and degradation of habitat. Recommendations included the establishment of coastal management areas, marine protected areas, or biosphere sites (Buzeta et al. 2003a).

16. Impacts from nearby activities threaten the ecological integrity of the highly biodiverse benthic communities found in HH/WI. Relatively un-impacted areas (e.g. West Isles), as opposed to those heavily utilized by marine industries (e.g. Letang Inlet), should be considered for protection (Brilliant 2001).

17. Being within a previously proposed protected area that would straddle the International boundary line for 16 km on each side (Gulf of Maine International Ocean Wilderness) (http://www.clf.org/uploadedFiles/CLF/General/Publications/c2c_sec5.pdf, accessed August 18, 2007)

18. The West Isles is the anchor for the Biodiversity Discovery Corridor (CMB 2007), an initiative that serves as focal points for collaborative scientific studies.

19. The spread of fishing effort to areas previously avoided reduces refugia for species vulnerable to disturbance, including juvenile fish such as *Gadus morhua*. Bottom trawling is likely detrimental to *Anarhichas lupus*, listed as a species of concern with COSEWIC, as it destroys or disrupts fish habitat (www.speciesatrisk.ec.gc.ca, accessed January 2007)

20. The concern that these areas have not previously seen much inshore dragging activity but are now being threatened with new developing fisheries (Bosien 2001). Dragging effort for sea cucumbers in the West Isles has been increasing, and analyses of the sea cucumber fishery data (Fig. 3) confirms this dragging effort overlaps with areas identified for their biodiversity and complex habitats (Voutier et al. 2006; M. Strong, DFO, Biological Station, St. Andrews, NB, E5B 2L9, pers. comm.)

21. The area being reviewed for significance/sensitivity to large-scale industrial development and any associated vessel traffic. It is recognized internationally, locally, and publicly by the Government of Canada (News releases), as an environmentally sensitive area. It seems timely and wise to review any activities, including new and developing fisheries and aquaculture expansions, that may be seen as contradictory to DFO's ecosystem-based management objectives (productivity, habitat, biodiversity), and to the risk aversion management suggested for EBSAs.

22. Present and future marine activities (fishing, aquaculture, tidal power, industrial coastal development) in the West Isles should be reviewed carefully before approvals or amendments in management plans to ensure a higher level of risk aversion for this area.

23. The risk of a whale–vessel collision in HH/WI, where right, finback and humpback whales are frequently observed, is considered high.

24. The need for the establishment of monitoring sites/surveys for the various trophic level aggregations, including benthic species richness, invasive species, and eutrophication indicator species.

Ecosystem objectives to consider are Habitat, Biodiversity, and Productivity.

III.E. THE PASSAGES

Reference to The Passages generally includes Big Letete, Little Letete, Pendleton, and Western Passages. Western Passage supplies 61% of the water entering Passamaquoddy Bay, while Big Letete Passage supplies 34%, and 5% passes through Little Letete Passage (Bumpus et al. 1959). Big Letete and Little Letete Passages are narrow high velocity channels north of Deer Island. The currents in these channels are caused by the frictional resistance of the tidal water movements against the complex benthic topography.

Ship Harbour (east side of MacMaster Island facing Letete Passage) is a sheltered harbour used as safe anchorage by boaters, and the gravel beach is commonly used for recreational picnics. MacMaster Island is the largest of the 40 small islands constituting the archipelago east of Deer Island, approximately 1.8 km^2. It contains one of the few saltwater ponds in the area.

Prior to European settlement, MacMaster Island was frequented by the Passamaquoddy Tribe. There are several shell midden sites on the island, and as members of the Passamaquoddy-Scoodic Tribe struggle to preserve their link to their heritage, places such as Ships Cove on MacMaster Island, on the southern shore of Big Letete Passage, become culturally significant. As a result there is interest in protecting the area (Akagi 2001). While cultural significance *per se* is not part of the EBSA assessment, statements made by the Passamaquoddy Tribe should be considered because the coastal communities that thrived were enabled by persistent environmental conditions (e.g. geomorphology, water temperature, currents, upwellings) that result in the aggregation of resources.

Many of the references to The Passages are the same as those for the HH/WI. This redundancy could have been avoided by combining The Passages with HH/WI. However, the authors felt that the review of smaller areas would assist managers when considering management options.

The Passages – Evaluation according to EBSA criteria

The information available provided a strong basis for workshop participants to recommend The Passages as an EBSA.

Recommendation is based on:
- Its species aggregations (benthic biodiversity, sponge species, avian species)
- Its environmental conditions (strong currents and benthic topography)
- Its environmental conditions that support avian life stage requirements.

Uniqueness

1. The Passages were included in the Head Harbour area short listed by Parks Canada/Tourism New Brunswick (1985) for protection, based on benthic surveys that described the walls rich in biota that make it unique.
2. The Passages are areas where current velocities are at the maximum ranges, and upwellings, convergences and rips are abundant. The high current velocities (2.5 $m{\cdot}s^{-1}$) and the substrate characteristics (cobble, boulder, ledge, vertical cliffs) of Little Letete Passage result in very rich benthic communities of organisms adapted to feeding in these extreme current conditions. The Passages generally, have very high percent cover of benthic organisms (Thomas 1983).
3. Previously unreported or rare sponge species, increased upright (e.g. *Haliclona oculata*) and massive (e.g. *Myxilla* spp.) sponge cover has been recorded, that is significantly correlated to vertical rock slope, boulder sides, and cliff sides, and a new species of sponge described not yet found anywhere else (Ginn 1997; Ginn et al. 2000).
4. Saltwater ponds on MacMaster Island are not commonly seen in the Quoddy region. These are home to sticklebacks and mummichogs, and to the birds such as herons and kingfishers, feeding on these fish and the numerous small crustaceans. Eagles are routinely spotted flying across the ponds and juveniles specifically seem to aggregate in springtime, if undisturbed.
5. Transects performed by Lawton (1992, 1993) did not find any commercially significant species (e.g. scallops, lobster) within the 10 m contour of the harbour. In the shallow waters of the harbour there are large numbers of sand dollars *Echinarachnius parma*, moon snails *Lunatia heros*, ridged neptunes *Neptunea decemcostata*, and the waved whelk *Buccinum undatum* (M-I. Buzeta, St. Andrews Biological Station, St. Andrews, NB, E5B 2L9, dive log 2000).
6. Recent GIS video surveys within The Passages demonstrate an abundance and diversity of epifauna including a large number of sponges. These videos are presently being analyzed (M. Strong, DFO, Biological Station, St. Andrews, NB, E5B-2L9, pers. comm.).

Aggregation

1. Tidal water movements against the complex benthic topography results in intense vertical mixing that brings plankton to the surface, making these areas particularly attractive to faunal aggregations (Smith et al. 1984).
2. The Passages are documented as important avifauna areas (Parks Canada/Tourism New Brunswick 1985; Diamond 2001).
3. Black guillemots, common eiders, red-breasted mergansers (*Mergus serrator*), scoters, and bald eagles (*Haliaeetus leucocephalus*), are common in and around Big Letete and Little Letete Passages (Thomas 1983).
4. Lawton (1992, 1993) states that the presence of vertical rock walls and high currents results in a highly diverse and abundant community of sessile organisms found in The Passages.
5. There is a high population density of filter feeding organisms, with a particularly diverse sponge community, as described by Ginn (1997), with potentially more species not yet described (Thomas 1994, 2001).
6. The Passages also sustain an extraordinary field of sea cucumbers *Cucumaria frondosa*, described by Thomas (2001) as being "paved with sea cucumbers", that in turn provide another sub-habitat for additional organisms, making the diversity extremely high.
7. There are also a large variety of anemones that live on the back face of the rock walls, away from the current. (Thomas 2001).
8. Thomas stresses that "all The Passages around the Deer Island Archipelago are really special" and represent one of the areas with the finest biodiversity for benthic organisms in the Bay of Fundy (Thomas 2001).

Fitness consequences

1. Little Letete Passage and other passages are considered important to larval settlement and food supply for filter feeders. Because there is such a huge amount of water going through, it's an opportunity for larval settlement and probably even more importantly, the food supply for filter feeders (Thomas 2001).
2. Current velocities are high enough in Little Letete to keep out a large population of sea urchins. Sea urchins have been cited as the organism responsible for creating "barren grounds," so in the absence of grazing by sea urchins, there is much better development of small attached organisms on the rock surface.
3. Western Passage and Letete Passage are used during the fall migration of Bonaparte's gulls and Arctic and common terns (Diamond 2001).

Naturalness and Resilience

1. These passages are considered to be very vulnerable to all kinds of damage (e.g. fishing) and they have an incredibly high biodiversity of organisms both intertidally and subtidally. Little Letete has high bottom current velocities, exceeding a meter per second, and probably double at the surface. These are exceptionally fast water currents, and it means there is a huge volume of water

moving through these passages, and that they pose problems for safe navigation (Thomas 2001).

2. Structurally complex benthic habitats, and long-lived upright epifauna such as the numerous sponge species recorded in The Passages (Thomas 1994; Ginn 1997), tend to be more sensitive to fishing disturbance. For example, sponge colonies found in the Gulf of Maine were found to be disturbed in areas of intense fishing (Auster et al. 1996). Disturbed benthic sites lacked epifaunal taxa, colonial species, non-burrowing anemones, shrimps, sponges, nudibranchs, small fish, and some species of tube worms (Collie et al. 2000).

3. The intertidal area on Little Ireland Island, in Little Letete Passage, has sedimentary associations because it is subject to strong currents. In Little Letete Passage there are only small amounts of sediments because most are winnowed out by the currents. But there are also some large, unstable sand ridges at the inner end of the passage which have large populations of anemones on them at times. Generally, this area is a very unstable place for organisms to attach (Thomas 2001).

4. Until recently, dragging occurred mostly in the deeper, soft sediments for scallops. More recently sea cucumber dragging has focused efforts in The Passages (Fig. 3) (Voutier et al. 2006).

The Passages - Management considerations

1. It is recommended that The Passages be managed as a unit along the adjacent HH/WI EBSA.

2. The Deer Island area has been considered for a marine park, inclusive of The Passages.

3. Pendleton Island is protected through the Nature Conservancy.

4. The Passages are considered worthy of protection. Little Letete is the best researched of The Passages, however, all The Passages display the finest biodiversity for benthic organisms in the Bay of Fundy. They are recommended for protection as a marine sanctuary, with no fishing of any kind, no moorings, and no shoreline development (Thomas 2001).

5. There are historical data and videos from studies done by the University of New Brunswick that might provide a benchmark for species diversity in The Passages. These should be recovered and compared to present-day videos.

6. Present and future marine activities should be reviewed carefully before approvals or amendments in management plans, to ensure a higher level of risk aversion for this area. While these areas have not previously been utilized, there is concern that they are now being threatened by development and inshore dragging (Thomas 2001; Bosien 2001). Analyses of the sea cucumber drag fishery confirm dragging efforts along the Letete Passage from MacMaster Island to Parker Island (Fig. 3) (Voutier et al. 2006; M. Strong, DFO, Biological Station, St. Andrews, NB, E5B 2L9).

Ecosystem Objectives to be considered for The Passages are Productivity, Biodiversity, and Habitat.

III.F. THE WOLVES

The Wolves – Evaluation according to EBSA criteria

Compared to the other areas being evaluated, information on this area is not overwhelming, and further studies may be required. However, this area exhibits the EBSA attributes of Aggregation and Fitness Consequences, based on knowledge that it is:

1. an important wintering area for the endangered Harlequin duck (Lotze and Milewski 2002) and seabirds (Brylinsky et al. 1996; Hicklin and Smith 1984);
2. an area of known lumpfish and other finfish spawning (Coon 1998; M-I. Buzeta, St. Andrews Biological Station, St. Andrews, NB, E5B 2L9, dive log 2002);
3. an area of benthic species aggregation (high species richness) (MacKay et al. 1978a-c,1979a-c; Buzeta et al. 2003a; Appendix 3).

Aggregation

1. Large variety of finfish (e.g. herring, pollock, tautogs), and a large diversity of sessile communities typical of strong currents (e.g. large sponges, tunicates) (MacKay et al. 1979b).
2. Shallow water immediately inshore used for feeding and staging by harlequins in winter, and eiders in summer (Diamond 2001).

Fitness consequences

1. The Wolves, and generally the outer Quoddy area including the numerous small islands, are important staging areas for seaducks, and support 2500 pairs of breeding common eiders (Brylinsky et al. 1996; Hicklin and Smith 1984).
2. The Wolves area is identified as an important wintering ground for the endangered harlequin duck (Lotze and Milewski 2002).
3. There are nearby records of haddock spawning and cod and lobster nursery areas (Coon 1998).
4. There is a record of lumpfish spawning in the shallow waters of South Wolf Island (M-I. Buzeta, St. Andrews Biological Station, St. Andrews, NB, E5B 2L9, dive log 2002).
5. Listed as an Important Bird Area (IBA 2001). Major breeding area of common eiders, wintering area for harlequin ducks, recent recorded breeding areas for razorbills (Mawhinny and Sears 1996).

6. The waters between Head Harbour Passage and The Wolves are a feeding area for finback, minke, humpback, and occasionally right whales (SENES Consultants Ltd. 2006).

The Wolves - Management considerations

Existing and new activities in this area should be reviewed for potential impact to these EBSA attributes.

Ecosystem Objectives to be considered are Productivity and Habitat.

III.G. MACES BAY

Maces Bay – Evaluation according to EBSA criteria

This area fits the EBSA criteria of Fitness Consequences (e.g. seabirds, lobsters) and Aggregation (e.g. seals), although information for the most part is restricted to avian and lobster requirements generally found in other areas evaluated.

Workshop participants agreed that on Maces Bay meets two of the EBSA criteria and based on its importance to the lobster and scallop life cycles it is recommended as an EBSA.

Aggregation

1. King eiders *Somateria spectabilis* are rarely seen in the Bay of Fundy, but have been recorded in Maces Bay (Brylinsky et al. 1996).
2. The ledges in the Maces Bay area provide ideal haulout locations for seals (Terhune 2001).
3. There is some evidence to suggest that berried female lobsters may aggregate in this area. Some were found during one transect along the eastern side of the French Ledges, and the southwestern side of Mole Island, and on the north side of Mole Island, depressions found in the sand were interpreted by experienced biologists to be those created by berried females. Several berried lobsters were also encountered during survey dives off the exposed areas of the Brothers Islands, and around Point Lepreau, suggesting some significance as a lobster nursery area (Lawton 1992, 1993). Additionally, anecdotal observations by experienced research divers suggested that densities of small juvenile lobsters were very high (Lawton 1992; Lawton, DFO, Biological station, St. Andrews, NB, E5B 2L9, pers. comm.).

Fitness consequences

1. The Maces Bay area was identified as Regionally Significant because of its significance to feeding and breeding sea ducks, brant *Branta bernicla*, shorebirds, gulls, terns and cormorants (Hunter and Associates 1982).

2. Maces Bay/Point Lepreau area has been designated an Important Bird Area (IBA). Each spring and fall, tens of thousands of seaducks including common eider and black scoter *Melanitta nigra*, travel through this area (IBA 2001).
3. The intertidal ledges are recognized as important staging areas for brant during their spring migration. This is considered a good area for inshore marine birds, as the rocky tidepools attract migrant shore birds in late summer, purple sandpipers *Calidris maritima*, and brant in spring. Gulls and other seabirds breed on the Salkeld Islands (Thomas 1983).
4. Areas along the coast of Point Lepreau west to Red Head, including Salkeld Islands in Maces Bay, and New River Island in Pocologan Harbour, are considered important to nesting colonies of common eiders, and important brood-rearing habitats (i.e. rockweed along mainland shore) (Diamond 2001).
5. High scallop spat densities were observed in the areas around Brothers Island and off Barnaby Head (Lawton 1992, 1993).
6. Within Maces Bay, Pocologan Island and French Ledges showed good juvenile lobster densities. In particular, the Pocologan Island-French Ledges area contained significant numbers of juvenile lobsters. The New River Beach-Barnaby Head area had a preponderance of immature lobsters, indicating that the area is an active settlement location. Relative abundance of lobsters in the Barnaby Head-Lepreau Harbour area indicates that the area is a prime lobster nursery habitat (Lawton 1992, 1993).
7. Substantial lobster and scallop nursery functions support nearby fisheries (Lawton 1992). Pocologan Island and French Ledges have high abundance of lobster juveniles and scallop spat (Lawton 1992).
8. Productivity in this area as related to the abundance of benthic invertebrates is recorded to be not as high as that of the West Isles or The Wolves (MacKay et al. 1979c).

Maces Bay - Management considerations

1. Further surveys or spot observations should be made to confirm reports of berried female lobsters.
2. Activities approved in this area should consider the impact on the ecological functions related to avian and lobster life cycle requirements.
3. Important research/monitoring sites for diversity of seaweeds are located in Maces Bay and Lepreau Harbour (Chopin et al. 2001).
4. There are concerns that these areas are threatened with siltation and eutrophication. Management recommendations specific to these seaweed study areas include establishment of a network of areas with enhanced management or protection that diminish the risk of anthropogenic impacts on long-term studies (Bates et al. 2001).
5. The Maces Bay area traditionally had several productive herring weirs (CCRM 1999). More recently it has become the site for several aquaculture

developments, including the conversion of some of these weir sites to aquaculture.

6. Maces Bay has been recommended as an aquaculture exclusion zone (Lawton 2000).
7. New River Beach is designated as a Provincial Park.
8. New River Island is a private nature reserve.
9. Eastern Habitat Joint Venture has purchased some coastal islands for protection, like the Brothers Islands near New River (Richard 2001).

Ecosystem Objectives to be considered are Productivity and Habitat.

IV. CONCLUSIONS AND RECOMMENDATIONS

i. There is a high degree of transferability among the previous assessment of significant areas and the present review.

The overall conclusion (PE 2006) on methodology is that there is a high degree of transferability of results reported in 2003 (Buzeta et al. 2003a) and the present review according to EBSA criteria. Table 3, based on workshop results, indicates this clearly. Because of this, areas previously identified as significant for endangered species, ecological significance, spawning, nursery, or staging areas, high productivity, or high biodiversity, could automatically be identified as EBSAs. This is an important finding that will assist in identifying other significant areas in the Bay of Fundy as EBSAs.

Table 4. Summary of assessment of areas reviewed, based on the evidence from the published literature, scientific and local knowledge, statistical analyses, and the EBSA workshop proceedings (Appendix 4).

Area	Uniqueness	Aggregation	Fitness Consequences	Naturalness[b]	Resilience[b]	Identified as EBSA[c]
Quoddy Region	Y	Y	Y	Y (overall)		e
St. Croix/ Passamaquoddy	-	-	-	Dragging[a] Aquaculture		-
Head Harbour (West Isles)	Y	Y	Y	Dragging[a] Aquaculture		Y[d]
The Passages	Y	Y	Y	Dragging[a]		Y[d]
The Wolves	-	Y	Y	Y		Y
Maces Bay	-	-	Y	Aquaculture		Y

[a] Refers to scallop, finfish, or sea cucumber dragging.

[b] Not considered in detail during workshop discussions (see Appendix 4). Requires directed research to assess.

[c] "Y" (Yes) indicates that the area meets at least one of the primary EBSA criteria.

[d] Considered hotspots within Quoddy and given the highest ranking for protection.

[e] Considered significant because of its components, but not identified as an EBSA, and it's individual components were evaluated.

ii. The Quoddy Region operates as a whole, and it is likely unique and irreplaceable for all of the Bay of Fundy.

The Quoddy Region was described by scientists present at the workshop as irreplaceable and unique within the Bay of Fundy, a conclusion previously recorded and explained by Larsen (2004): "From a geological time perspective, scientists suggest that the Quoddy Region is ecologically unique as a result of recent and rapid geological evolution. It is these rapid changes in geology and oceanography that have occurred since the last glaciation, that have resulted in the present distribution and richness of biota".

No matter what the designation, through its components, the Quoddy Region meets all EBSA criteria (Table 4). There is a strong consensus that the entire Quoddy Region should be managed by applying risk aversion, and because areas within Quoddy are interdependent there is concern with priority setting for some areas within it and not for others. However, for management purposes, conclusions and recommendations on the components within it, Head Harbour / West Isles, The Wolves, and Maces Bay, are presented separately.

iii. Head Harbour / West Isles Archipelago / The Passages (HH/WI) have clearly and unquestionably satisfied all the primary EBSA dimensions - Uniqueness, Aggregation and Fitness Consequences criteria.

These areas were considered to be the hotspots within the Quoddy Region, and given the highest priority ranking for protection by all participants. It was strongly suggested that these components should be considered as one area. It was noted that it is closely linked to Cobscook Bay, which should be included. Additionally, the body of water passing through this EBSA should be subject to monitoring and precautionary management.

The approximate size of the proposed HH/WI EBSA is 70 km^2, or a total of 86 km^2 including The Passages.

HH/WI and Passages had been previously identified by experiential and scientific ecological knowledge and in the scientific literature using "criteria of the day". These areas have substantial information, far more than what is available for other areas, and form the basis of this assessment (Table 4). There is also a statistical basis for supporting environmental factors as contributing to the higher species richness found in this area (Appendix 3).

HH/WI and The Passages provide opportunities for developing and testing near-shore EBSA management approaches. A proactive, precautionary management approach is suggested (see below Section v: Management red flags), in order to maintain the ecosystem health of near-shore areas in the Bay of Fundy.

iv. The Wolves and Maces Bay also satisfy EBSA criteria.

The Wolves satisfies the primary criteria of Aggregation and Fitness Consequences, and the secondary criteria of Naturalness (Table 4). It was noted that it is especially important for birds, and that its remoteness was a factor in the extent to which it meets the secondary dimension of Naturalness.

Maces Bay satisfies the primary dimension of Fitness Consequences (Table 4). Workshop participants noted that it is important to the Quoddy Region and surrounding area for lobster. Information required to evaluate Maces Bay with respect to the other EBSA criteria was lacking.

v. Immediate precautionary measures and a high level of risk aversion in management decisions are recommended.

All these areas, Head Harbour, The Wolves, and Maces Bay, meet at least one EBSA criteria, and therefore should be placed on a priority list for long-term protection, based on knowledge that the areas most likely to be impacted are those in the shallow coastal zone. It is in these coastal areas where most human activities occur (Hiscock 1999), and where cumulative impacts of large-scale industrial developments (e.g. liquid natural gas, in-stream ocean energy), along with habitat-specific impacts from activities (e.g. eutrophication, enrichment, habitat alteration and destruction) are most likely to accrue.

Habitat conservation is one of DFO's ecosystem objectives, and so *"should become one the primary operational principles of fisheries management"* (Gordon et al. 2006). To accomplish this objective, a full review of all ongoing and proposed activities within Head Harbour, Maces Bay, and The Wolves areas, should be immediately carried out, in order to assess potential threats to these coastal areas identified as EBSAs.

The impact of energy extraction by in-stream power turbines, within the area of Head Harbour / West Isles archipelago, and The Passages, an area known for significant productivity and richness associated with this energy, should be carefully evaluated prior to any developments. The tidal currents and upwellings found here are attributes that are key to this ecosystem, resulting in significant aggregations of resources and plankton that attract migratory species such as whales, including the endangered Right whale, seabirds, and herring. The impact of a decrease in tidal energy, or a change in flow patterns, on these resources and migratory paths, is unknown.

Management decisions for these areas should address fishing activities known to specifically impact benthic communities (e.g. dragging, dredging), so as to prevent irreversible harm by degrading habitat and ecosystem functions; and precautionary management should be adopted for marine activities that have a potential for degrading water quality leading to eutrophication or sedimentation (e. g. increase in organic load from aquaculture, re-suspension of sediments by dragging).

Based on local knowledge (Bosien 2001), and mapping (Voutier et al. 2006; M. Strong, DFO, St. Andrews, NB, E5B 2L9, pers. comm.), fish dragging efforts in HH/WI overlap with areas identified as having diverse benthic invertebrate habitats. Structurally complex benthic habitats, such as that found in HH/WI, tend to be more sensitive to fishing disturbance. Additionally, bottom disruption removes or damages large attached epifauna, reducing the habitat complexity that harbours small fish, and decreasing diversity and productivity (Auster et al. 1996; Collie et al. 1997; Gordon et al. 2006).

Management red flags

It was noted that while red flags will be different for each area, in general management considerations and decisions must consider the attributes listed throughout this discussion. The Head Harbour / West Isles / The Passages / Cobscook area is clearly ecologically and biologically significant.

The hydrodynamics resulting from the geomorphology and tidal flux that provide the energy required for the productivity and upwelling of food sources that support unique assemblages and feeding aggregations need to be considered (e.g. tidal power initiatives). Also important are topographic complexity, substrates, and circulation patterns that provide the benthic habitat and advection of larvae and resources that support high biodiversity.

There are multiple layers of activities occurring or planned for these areas that in isolation may not trigger a red flag. Therefore, there is concern that with continuous expansion of each activity (higher frequency, more intensity, larger scale), the individual effects of each will need to be considered cumulatively.

A key for management of these EBSAs will be to remember that naturalness is at the other end of the perturbation/degradation scale, and that as naturalness decreases, so will the other primary EBSA dimensions.

If the historic value of St.Croix River and Passamaquoddy Bay were to be considered, these areas could have easily been identified as EBSA in the past, yet today they are good candidates for recognition as highly degraded areas, and as such have been subject to several remediation initiatives.

The following recommendations have been suggested by Gordon et al. (2006) in order to reduce the impact of mobile fishing gear on benthic habitat:

- Control fishing effort to very small spatial scales.
- Select the least damaging gear type for a given habitat, especially in sensitive habitats such as hard bottoms with abundant, sessile, slow growing epifauna.
- Establish area closures as an effective measure in protecting benthic ecosystems, which provide refugia for new recruits, and long-term monitoring benefits.

This exercise was an assessment that focused on the ecological and biological information available. It was noted that the workshop recommendations primarily relate to the application of EBSA criteria. For management decisions, other evaluations would be needed related to human-centric elements (e.g. cultural, economic). Management considerations included are offered in an attempt to reduce or prevent a potential for impact on the EBSA attributes for which these areas have been identified. Whether old or new criteria are applied, Quoddy is ecologically significant, and particularly the hotspots identified within that operate as a unit. Head Harbour / West Isles, The Passages, and Cobscook Bay, were the highest ranked areas for requiring protection from habitat-degrading activities.

V. FIGURES

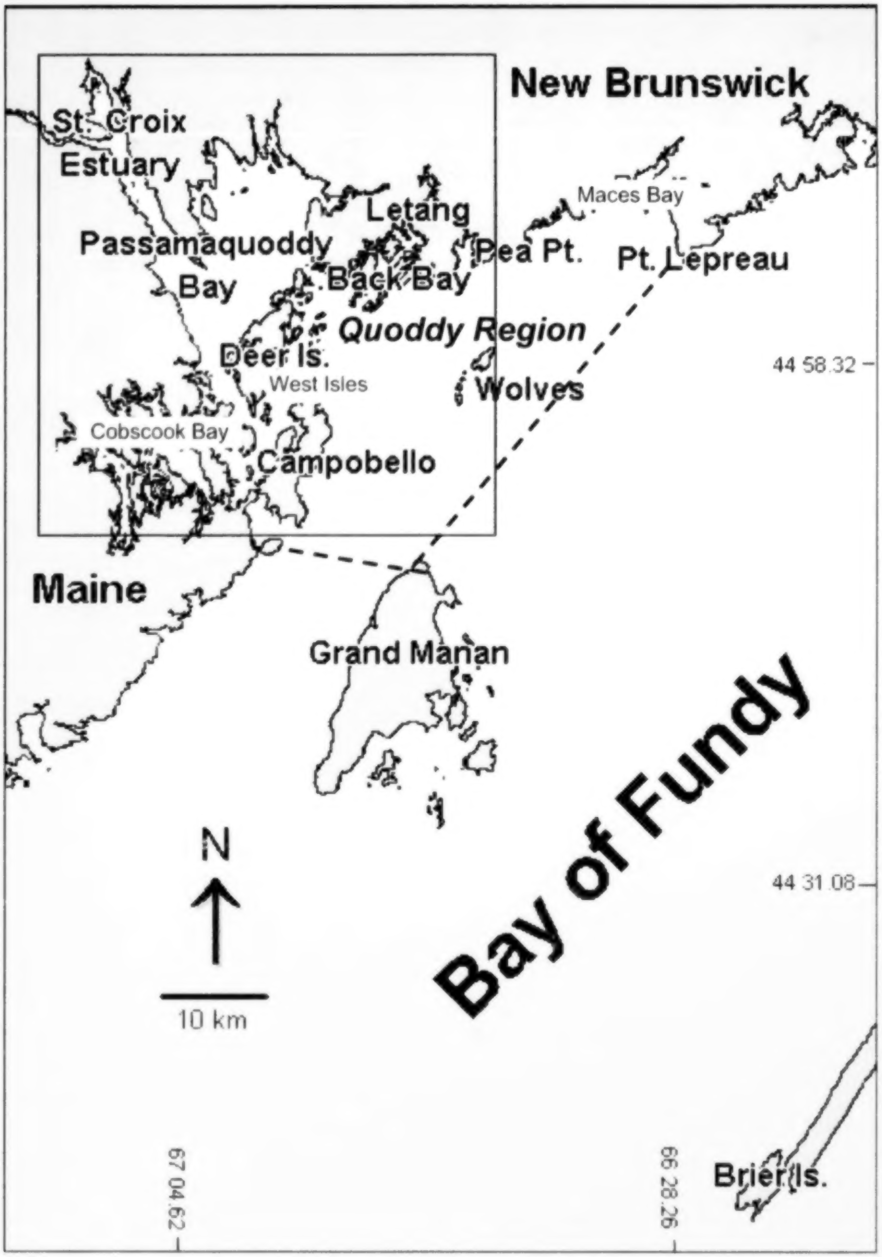

Fig. 1 (a). The Quoddy Region boundary (dotted lines) as defined by Thomas (1983), and locations of major regions. Detail for insert area is shown in 1(b), and used for statistical analyses in Appendix 3. Passamaquoddy Bay-St. Croix Estuary (PB), Back Bay-Letang Inlet (BBLI), Deer Island-Campobello Is. (DICI), Pea Point-Point Lepreau (PPPL), The Wolves (WOLV), Grand Manan (GM), Brier Island (BRIER).

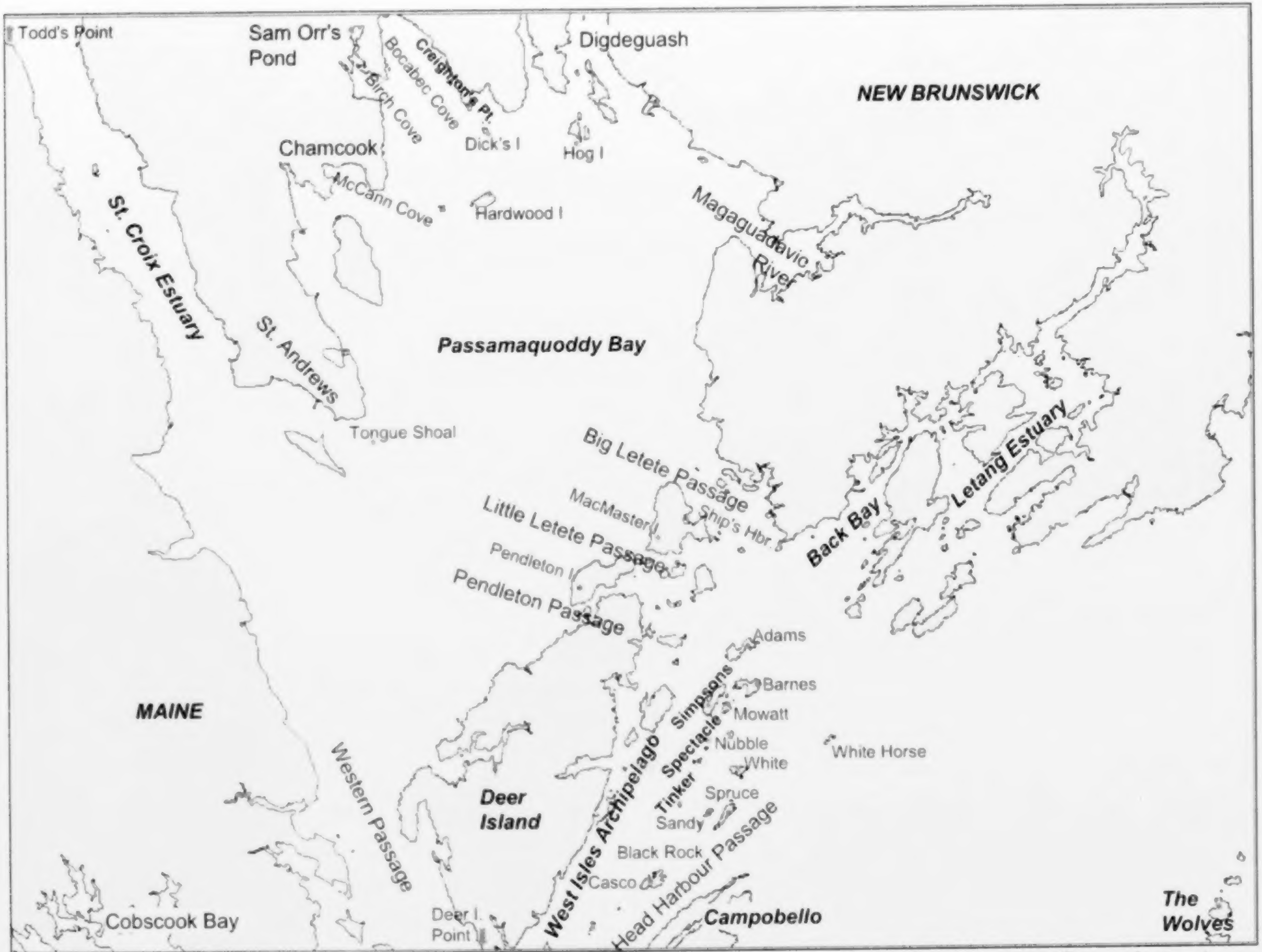

Fig. 1 (b). Place names within the Quoddy Region, and areas described as significant in text.

Fig. 2. Location of sites described in the literature as significant (stars) within HH/WI, boundaries proposed for protection/conservation by Parks Canada/Tourism New Brunswick (1985) (outlined area), and boundaries proposed by Marine Conservation Biology Institute (rectangular box).

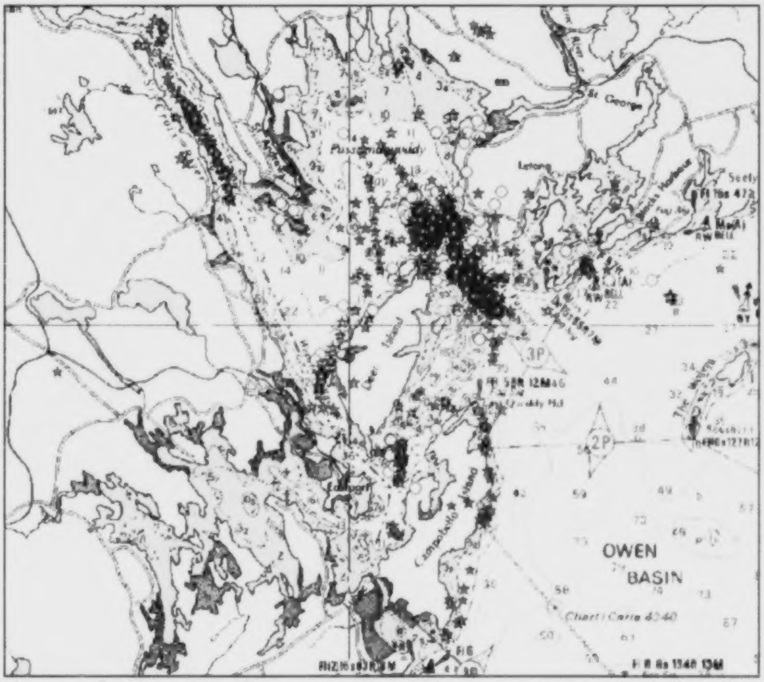

Fig. 3. Locations of dragging for sea cucumber, as recorded for the commercial landings database (white dots) and the science data log (black stars) (J. Voutier, DFO, Dartmouth, NS, B2Y 4A2; M. Strong, DFO, Biological Station, St. Andrews, NB, E5B 2L9, pers. comm.).

Fig. 4. Multibeam imagery of Passamaquoddy Bay and Head Harbour (West Isles). The depth gradient depicted is: light grey = shallowest, black = deepest (University of New Brunswick – Ocean Mapping Group).

Fig. 5. Locations of Atlantic wolffish pairs recorded by divers.

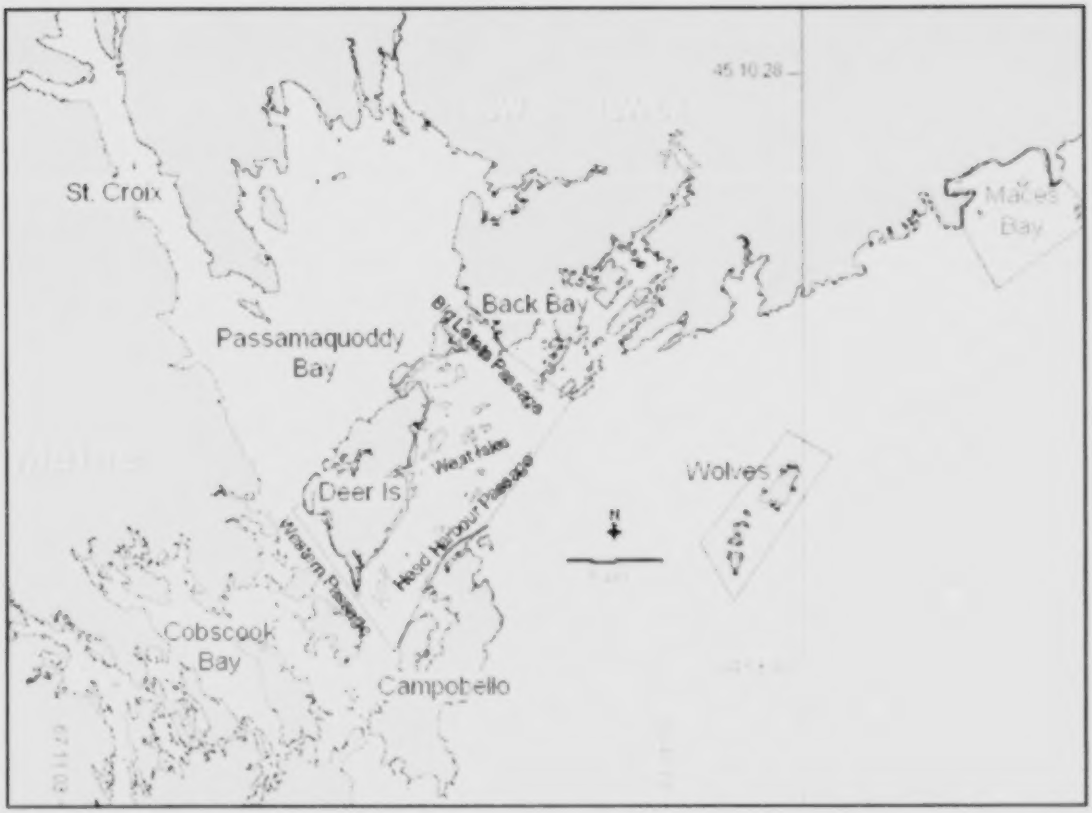

Fig. 6. The three EBSAs recommended (shaded areas), Head Harbour / West Isles / Passages, The Wolves, and Maces Bay. Boundaries are meant to include sites described, but are for demonstration purposes only.

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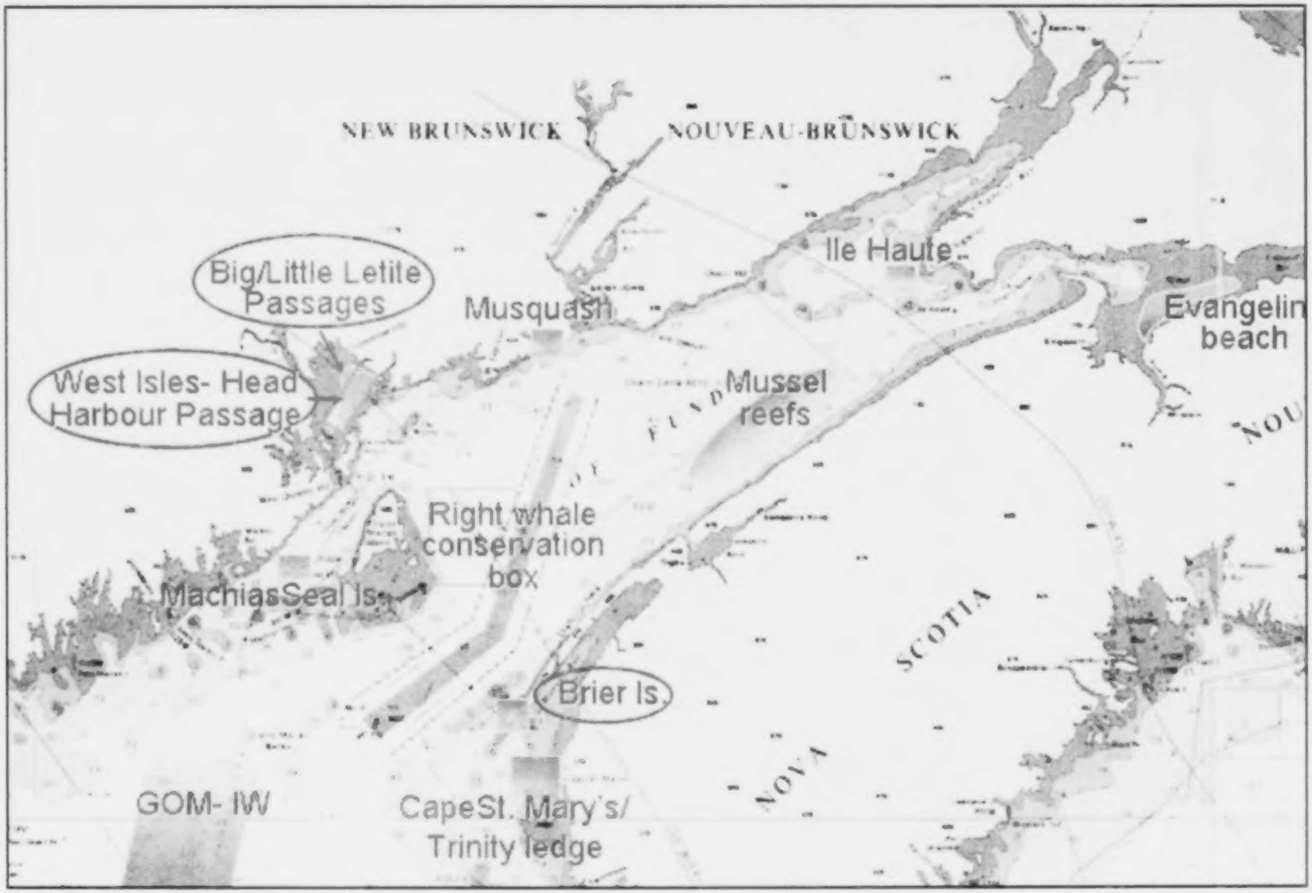
APPENDIX 1: List of significant areas from Buzeta et al. (2003a).These sites are to be re-reviewed using EBSA criteria.

Site name	Endangered /Threatened species	Productive, Resources	Unique / ecologically significant	Spawning/ larval/nursery/ staging area	Bio-diverse	Education, research, monitoring	Recommendat-ions for protection.
Grand Manan and area							
Flagg/Whale Cove		√	√	√		√	
Southwest Grand Manan		√		√		√	
Machias Seal Island	√				√	√	√
Right Whale Conservation	√			√		√	√
Quoddy Region							
Passamaquoddy Bay, St. Croix				√		√	√
West Isles	√	√	√	√	√	√	√
The Passages	√	√	√	√	√	√	√
White Horse, The Wolves		√		√		√	
Maces Bay				√		√	
Musquash							
Musquash estuary		√	√			√	√
Inner Bay of Fundy							
Chignecto Bay	√			√		√	√
Minas Basin		√		√		√	√
Other areas							
NS Shore and Brier Island	√	√	√	√	√	√	√
Fish spawning areas; coastal juvenile areas		√		√			√
Mussel reefs (Bioherms)		√	√				√
Migratory bird staging areas	√	√		√		√	√

APPENDIX 2: Map of areas identified as significant in 2003 (Buzeta et al. 2003a), and to be re-assessed in the future using EBSA criteria. Notable sites (circled) met 6-7 of the 7 criteria used in 2003.



APPENDIX 3: Statistical analyses of benthic species richness in the Quoddy region.

M-I Buzeta, DFO, Biological Station, St. Andrews, NB, E5B 2L9J.

Data and contributions by A. A. MacKay, S. C. Robinson, J. C. Roff, and M. Greenlaw.

The objective in this section was to provide an understanding of the factors that contribute to species variability in the Quoddy Region and to the higher species richness purported for the Head Harbour / West Isles (HH/WI) and The Passages. The statistical analyses provided the scientific underpinning for the preponderance of information and recommendations for protection identified for this area, and for the rationalization of the HH/WI and The Passages area as EBSAs.

To be effective in biodiversity conservation, management goals must be based on a solid understanding of the factors (e.g. hydrographic, physical, and structural), and processes (e.g. larval dispersal, colonization, and competition for resources) (Cornell and Karlson 2000; Levington 2001), correlated with species assemblages and species diversity, within the context of the marine region being managed. Traditionally this correlation has been visualized as overlapping of information onto maps. The disparate datasets available for the Quoddy Region utilized different scales, different names for regions and sites, and slightly different but overlapping boundaries for each region. For example, the HH/WI area overlaps with MacKay's Deer Island-Campobello Island (DICI) region (see Fig.1 of main document).

Analyses explored the relationships of hydrographic factors and structural features, with species assemblages and species richness, and were constrained to macrobiota of shallow (< 30 m), hard or mixed substrate, benthic communities. Methods were described in Buzeta et al. (2007).

Benthic species assemblages

- The individual sites surveyed by MacKay et al. (1978a-c, 1979a-c), shown in the multidimensional graph (Fig. A.1), group together by geographic regions according to similarity in species assemblages.
- Species assemblages were significantly discriminated (R = 0.455) on the basis of the average and range in temperature and salinity in the four hydrographic regions, T1-T4 (Table A.1.a). Locations of hydrographic sampling and regions of hydrographic similarities (Robinson et al. 1996) are shown in Fig. A.2.
- Geographic region and geomorphology also contribute to the variability among species assemblages, but show a weak statistical correlation (Table A.1.a).

Benthic species richness

- Species accumulation curves (Fig. A.3) show the contributions of each region to the total species list. DICI overlaps with HH/WI and had the highest species accumulation curve.

- DICI (33.2 ± 22.4) and WOLV (The Wolves) (32.8 ± 8.62) had the highest average species richness of the seven geographic regions examined. Average overall richness for all seven regions was 21.5 ± 15.5 (Fig. A.4). The high variability in species richness for DICI (± 22.4), was examined within subregions. The subregion along the Deer Island coastline facing southeast towards the West Isles (DI-WI), and the subregion comprising the smaller islands, reefs and ledges of the West Isles itself (WI), are part of the Head Harbour (West Isles) area. These two subregions, DI-WI and WI, had the highest values of benthic species richness found among all regions examined (58.3 ± 19.68 and 53 ± 15.28, respectively).
- A value of 50 species was chosen as a threshold for "high" species richness, based on the fact that 50 is approximately half the maximum number (95) of species found in any individual site. 6.05 % of sites examined exhibited 50 or more species, and 77 % of these were in the West Isles (Fig. A.5).
- Differences in species richness among geographic regions were significant (H = 60.05, p < .0001), and were mainly attributed to the species richness of DICI and WOLV (Wilcoxon scores > expected under H_0; Table A.1.a).
- A significant difference in species richness among hydrographic regions T1-T4 (Robinson et al.1996) shown in Fig. A.2 was found using the Kruskal-Wallis test (Zar 1999). H = 46.52, p < .0001, and T4 has the highest Wilcoxon score (Table A.1.a).
- There is a geographic overlap among hydrographic region T4 (Robinson et al. 1996), geographic region DICI, and sites with the highest species richness (Fig. A. 6).
- The Kruskal-Wallis test (Table A.1.a) also confirmed the significant difference of species richness among areas of different geomorphology defined by chart information and local expertise. Wilcoxon scores identified sites within the Archipelago as being the main contributors to the significant difference in species richness.
- DICI (HH/WI) was found to have the highest (5.47), and The Wolves (5.37) the second highest, benthic complexity values of the areas examined (Fig. A.7), as calculated from multibeam data. A positive, and significant, correlation (R^2 = 0.86) was found with average species richness (Fig. A.8) (Greenlaw et al. 2007).

Table A.1. Summary of significant correlations between benthic species assemblages and factors explored. Significance is detected when the correlation statistic > the random distribution of correlation values generated by ANOSIM (Clarke and Gorley 2006); significance level < 0.0001.

Factor	Random distribution range	*R / Rho* Statistic
Hydrographic regions (T1-T4)	-0.070 to 0.110	0.455
Geomorphology	-0.050 to 0.055	0.165
Geographic region	-0.045 to 0.060	0.141

Table A.2. Significance tests of species richness [MacKay et al. (1978a-c, 1979a-c)] (a) among geographic regions, hydrographic regions, and geomorphology, and pair-wise tests to identify the highest contributions (Wilcoxon Scores > expected under H_0); and (b) correlation (R^2) with highest benthic complexity.

(a)

Factor	Data source	df	Chi-Square	Wilcoxon Score	Top Scores
Geographic region	MacKay et al. (1978a-c,1979a-c)	6	60.05*	296	WOLV
				278	DICI
Hydrographic regions	Robinson et al. (1996)	3	46.52*	91	T4
				78	T3
Geomorphology	Buzeta (2007, unpublished)	3	41.69*	296	Archipelago
				216	Open coastline

* Kruskal Wallis test, significance level < 0.0001

(b)

Factor	R^2	df	Highest average benthic complexity
Benthic complexity	0.86	3	DICI – WI, WOLV

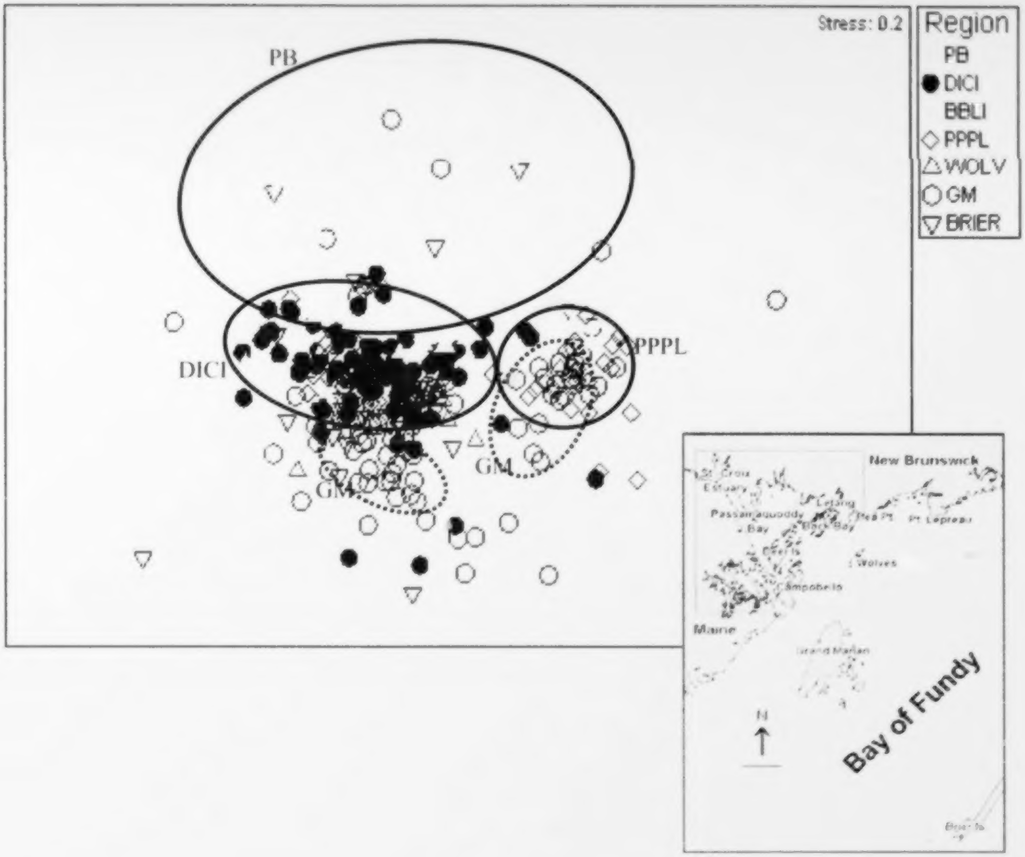


Fig. A.1. Multidimensional (MDS) representation (Clarke and Warwick 1994) of similarity in species assemblages (MacKay et al. 1978a-c, 1979a-c) of sites in the seven geographic regions shown on chart. Individual sites (n = 430) labeled by *a priori* geographic regions: Passamaquoddy Bay-St. Croix Estuary (PB), Back Bay-Letang Inlet (BBLI), Deer Island-Campobello Is. (DICI), Pea Point-Point Lepreau (PPPL), The Wolves (WOLV), Grand Manan (GM), Brier Island (BRIER). Free-drawn envelopes mark prominent aggregations of sites within each geographic region: PB, DICI, PPPL (solid lines) and two clusters within GM (dotted lines). DICI overlaps with HH/WI.

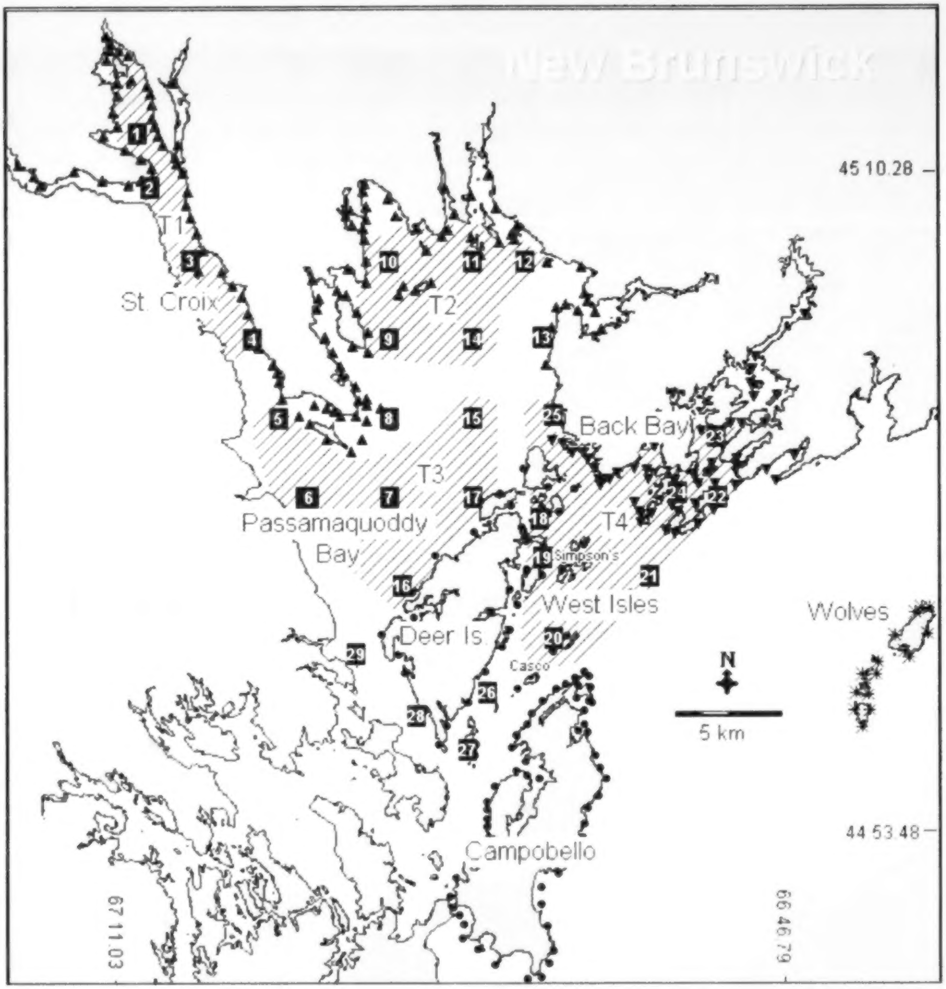


Fig. A.2. Locations of geographic regions and sites for biological data (MacKay et al. 1978a-c, 1979a-c) labeled as: St. Croix Estuary-Passamaquoddy Bay (PB) = ▲; Back Bay-Letang Inlet (BBLI) = ▼; Deer Island-Campobello Island (DICI) = •; The Wolves (WOLV) = *; and Brier Island and Grand Manan (not shown). Hydrographic (CTD) stations labeled 1-29 = ■; hydrographic regions (Robinson et al. 1996) T1-T4 (diagonal lines); hydrographic region T9 (grey dots). HH/WI overlaps with DICI-WI.

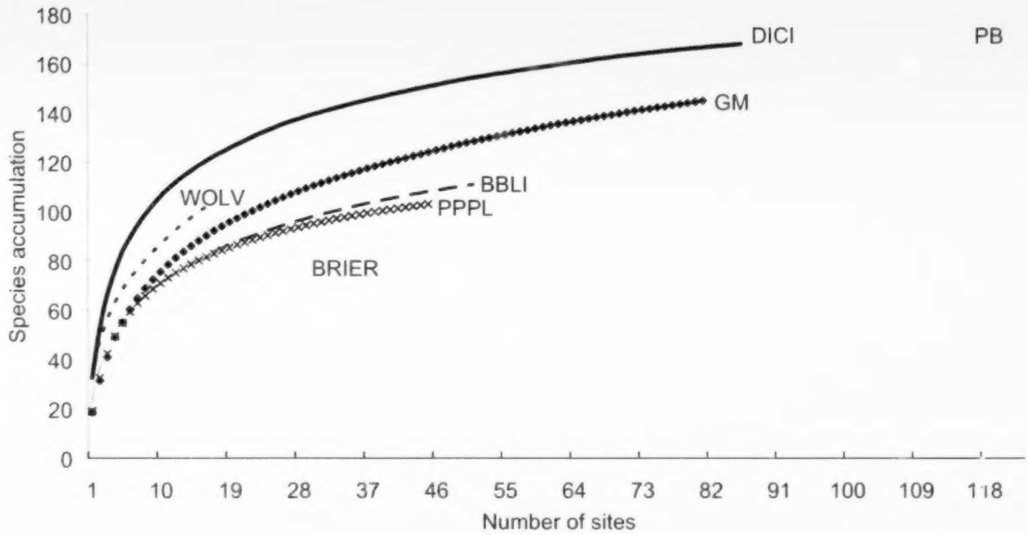


Fig. A.3. Species accumulation curves for benthic species recorded by MacKay et al. (1978a-c, 1979a-c), for each of the seven geographic regions. Each site represents a 100 m transect. PB = Passamaquoddy Bay-St. Croix Estuary, BBLI = Back Bay-Letang Inlet, DICI = Deer Island-Campobello Island, PPPL = Pea Point-Point Lepreau, WOLV = The Wolves, GM = Grand Manan, BRIER = Brier Island. The Region DICI overlaps with HH/WI, and exhibits the highest species accumulation curve.

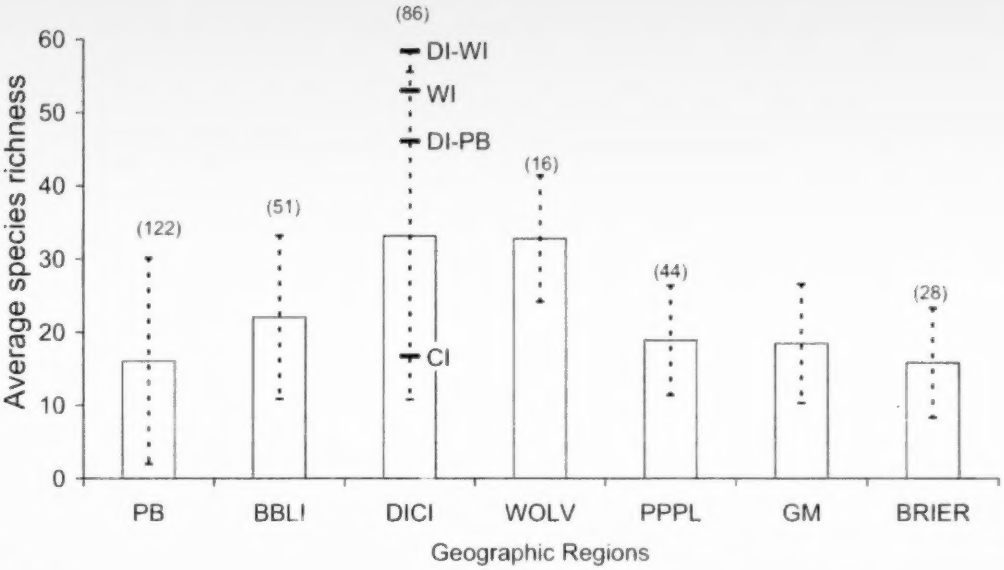


Fig. A.4. Average species richness ± standard deviation (dotted lines), number of samples (n) for geographic regions, and contribution of sub-regions (black bars) to the greater range of values found in DICI. PB = Passamaquoddy Bay-St. Croix Estuary, BBLI = Back Bay-Letang Inlet, DICI = Deer Island-Campobello Island , PPPL = Pea Point-Point Lepreau, WOLV = The Wolves, GM = Grand Manan, BRIER = Brier Island, CI = Campobello Is. only, DI-WI = Deer Island sites facing West Isles, DI-PB = Deer Island sites facing Passamaquoddy Bay, WI = West Isles only. Geographic regions ordered according to proximity to each other. Subregion WI overlaps with HH/WI.

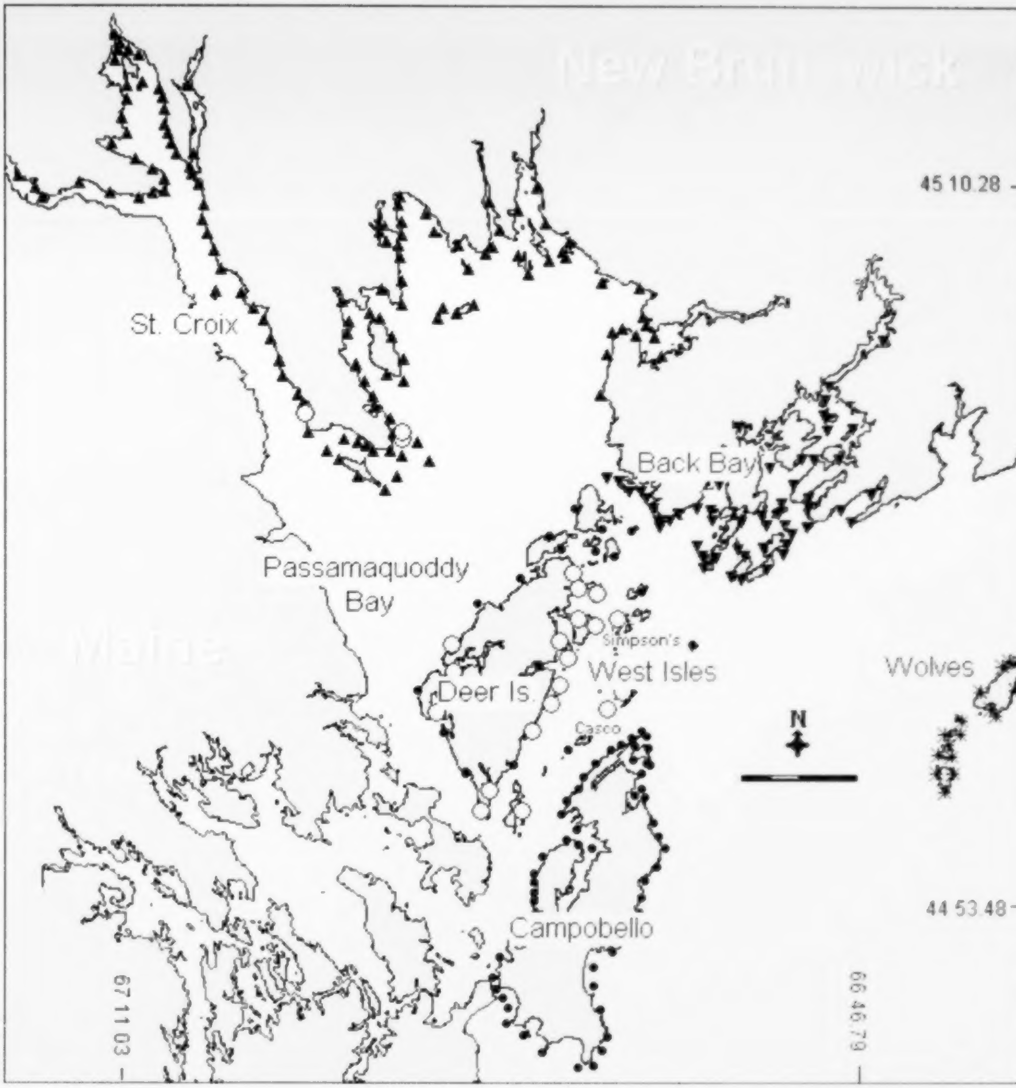


Fig. A.5. Sites surveyed by MacKay et al. (1978a-c, 1979a-c) exhibiting 50 or more species (circles) among all sites surveyed: Passamaquoddy Bay-St. Croix Estuary (PB) = ▲; Back Bay-Letang Inlet (BBLI) = ▼; Deer Island-Campobello Is. (DICI) = •; The Wolves (WOLV) = *.

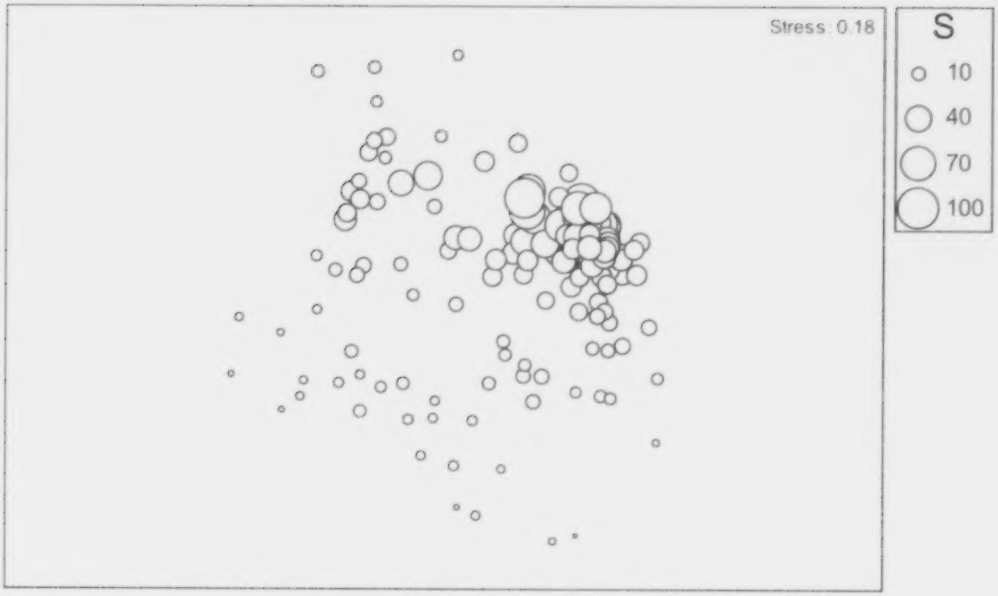


Fig. A.6. Multidimensional ordination of species assemblages for the subset of sites MacKay et al. (1978a-c, 1979a-c) within hydrographic region T4 (Robinson et al. 1996), labeled by increasing species richness S. Envelopes drawn by eye identify sites within hydrographic region T4 (solid line), and geographic region DICI (dashed line).

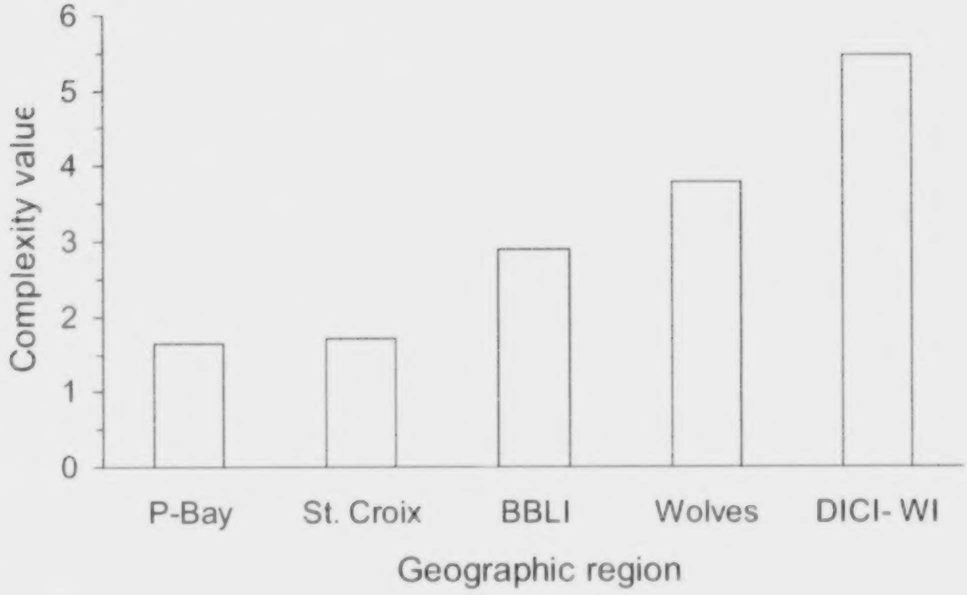


Fig. A.7. Average benthic complexity of five regions examined, highest complexity values were found in DICI and The Wolves (Greenlaw et al. 2007).

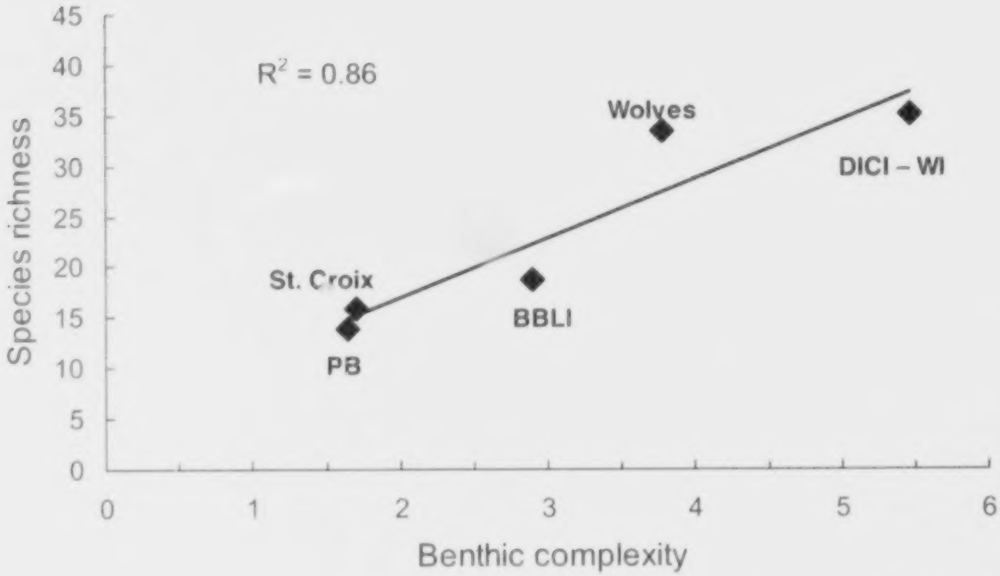


Fig. A.8. Average regional complexity significantly correlated to average species richness (MacKay et al. 1978a-c, 1979a-c) of five regions examined. Highest complexity was found in DICI (overlaps with HH/WI) and The Wolves (Greenlaw et al. 2007).

Conclusions drawn from statistical analyses

Results showed that the *a priori* grouping of sites by MacKay et al. (1978a-c,1979a-c), based on experiential knowledge, converged with statistical analyses that verified the cluster of points as similarities among species assemblages, and that these were significantly correlated to habitat characteristics of those regions.

The hydrographic conditions that characterize regions T1-T4 explained a large portion of the variability in species assemblages.

Sites with higher species richness were found among the West Isles Archipelago (area where DICI and T4 overlap), an area with a deeper photic zone, lower average temperature and higher average salinity, decreased variability in temperature and salinity, and higher benthic complexity as calculated from multibeam data.

Additionally, the overall combination of persistent habitat characteristics found to be correlated to a different benthic species assemblage or higher than average benthic species richness is not generally found among the other regions examined.

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APPENDIX 4: Proceedings of the Science Review of Ecologically and Biologically Significant Areas in the Quoddy Region. February 25-26 2008, St. Andrews Biological Station, NB.

B. Smith, B. L. Smith Groupwork, NS

1. Workshop Introduction

On February 25-26, 2008, an invitational workshop was held in St. Andrews New Brunswick to discuss Ecological and Biologically Significant Areas (EBSAs) in the Quoddy Region of the Southwest Bay of Fundy. This workshop provided an opportunity to review the methodology, the information available, and the conclusions drawn for areas identified in the Quoddy Region (Fig. 4.a). This was the science portion of the review of significant areas using criteria defined by DFO (http://www.dfo-mpo.gc.ca/CSAS/CSAS/status/2004/ESR2004_006_E.pdf).These proceedings provide a record of discussions, conclusions and recommendations from the workshop.

Fig. 4. a. The Quoddy Region.

Specific objectives

1. To assess if the EBSA criteria could be used productively in coastal areas with limited information, using the Quoddy Region, Bay of Fundy, as an example;
2. To ensure a common understanding of the current state of knowledge for the Quoddy Region as it applies to these criteria (Section 2);
3. to review and assess the transferability of information & criteria used in Table 3, Comparison of criteria (Section 3);
4. To apply the reference information listed to assess the six areas and to populate Table 4 EBSA attributes for areas reviewed in this report (Section 4);
5. To discuss topics such as naturalness, resilience and others (Section 5);

6. To review and assess report conclusions and provide recommendations, and consider next steps (Section 6).

Workshop format

In order to minimize the time required for a workshop, participants were requested to be familiar with the background documents provided, specifically the information listed for each of the six areas.

Initial presentations provided background on the EBSA process for the Scotian Shelf, as well as information on the research and assessment of ecological significance of the Quoddy Region.

There were two formats for discussion: plenary discussions, and breakout discussion groups consisting of a lead (a member of the Expert Panel 2006) and 6-8 participants. Each breakout group was assigned a specific criterion that was used to assess each of the six areas. Assessment of specific areas was based on one of the three primary DFO 2004 EBSA dimensions: uniqueness, aggregation and fitness consequences.

On Tuesday (Day 2) morning a number of topics were discussed, in addition to a review of the assessments of the previous day. The conclusions and recommendations from the workshop are outlined in Section IV of the main report. The agenda and a list of the workshop participants are provided in Sections 5 and 6 of this Appendix.

2. Background

It was noted at the outset of the workshop, that the purpose of the workshop was to apply the EBSA dimensions to areas within Quoddy as an assessment tool, to see if they meet the various criteria. The workshop brought together key scientists and researchers to consider the available information and assess six specific areas for their ecological and biological significance based on the criteria set out by Fisheries and Oceans Canada for recognition of Ecologically and Biologically Significant Areas (EBSAs).

A large body of research exists regarding significant ecological and biological areas in the Southwest Bay of Fundy, and specifically for the Quoddy Region. That research was synthesized in 2003 [Buzeta et al. 2003]. The 2003 report used a range of criteria from the scientific literature, regional scientific experts, and traditional and local knowledge.

In 2004 DFO developed a national set of criteria (dimensions) that would be used to assess and confirm Ecologically and Biologically Significant Areas (EBSAs). The primary criteria are uniqueness, aggregation and fitness consequences; and the secondary criteria are naturalness and resilience.

In 2006, a six person expert panel was asked to review the existing documentation, including the 2003 report, and determine if (or to what extent) the conclusions drawn on the original criteria were transferable to the 2004 DFO criteria. The panel determined that there was a high degree of transferability.

This 2008 workshop for scientists was intended to apply a systematic approach to reviewing the existing information and determining if there is sufficient evidence to draw conclusions regarding specific areas based on the 2004 criteria. The results of this workshop were incorporated into the final 2008 report (main document).

3. Assessment of areas – Key points

The three discussion groups each considered one of the three primary EBSA dimensions, uniqueness, aggregation, and fitness consequences for all six of the areas being reviewed. The groups were asked to consider the reference material provided and indicate whether or not they were considered to be relevant. They were asked to conclude whether or not the area met the requirement for their dimension, and to prioritize the areas.
For purposes of this review, each reference listed under a geographic area and EBSA attribute was numbered (see Section III of main document). Participants were asked to note this number along with their assessment of that information.

An evaluation of an area as EBSA by participants was denoted as "Yes", along with a ranking value.

Area	**Uniqueness**
Quoddy Region	1 (geological and oceanographic features) fault zone; earthquakes; methane pockets; see Kelly & Kelly (2004); geological features are very important at a large scale (NB/BOF). 2 (tides, currents, islands). 3, 4 (5 is the same as 1) define Quoddy Region as box on page 39 or even smaller area. Yes – priority #3
St. Croix/ Passamaquoddy Sam Orr's Pond Tongue Shoal Inner Quoddy	Little information – not strong enough
Head Harbour (West Isles)	1-8 add nutrients (Garside, C., and Garside, J.C. 2004. Nutrient sources and distributions in Cobscook Bay. Northeast. Nat. 11 (2): 75-86); need geological background. Very strong endorsement. Yes- priority #1

The Passages	2-6 apply, including Western Passages. Need geological background. May/should merge with West Isles/Cobscook. Noted several additions to documentation. Yes – priority #2
The Wolves	Right whale aggregation (Brilliant pers. comm.) (#6 Fitness)
Maces Bay	Pocologan clam flats – unique on the small scale but Upper Bay of Fundy also has this feature.

Area	**Aggregation**
Quoddy Region	References 1, 2, 3 apply. Missing references for birds, finfish, and herring aggregations. Significant for a variety of species for aggregation; regionally significant aggregations at the local scale. The question was asked if Grand Manan should be included. Yes – no priority given
St. Croix/ Passamaquoddy	Salmon, gaspereau. Ref 1 and ref 2 Missing references for sea ducks.
Sam Orr's Pond	Geomorphologically unique; no aggregations; only a special small ecosystem.
Tongue Shoal	Add bird literature.
Head Harbour (West Isles)	Lots of evidence; literature on birds lacking; bonapartes terns, eagles, razorbills, phalaropes; remove emphasis on gannets. Regionally and nationally important, perhaps globally. Minke whales lacking references. Big Yes – priority # 1
The Passages	Regionally and nationally significant, group with Head Harbour. Birds well covered, plankton inducing a lot of significance. Big Yes – priority #1
The Wolves	Eiders, overwintering harlequin ducks, kelp beds; right whales occasionally; juvenile humpbacks. Do not group The Wolves with Head Harbour and Passages. Locally significant for many bird populations, eiders regionally significant; decline in phalaropes.
Maces Bay	Common eiders should be added to references, Elsids; Reference to thesis by D. Johnson. Locally significant bird

populations; migratory corridor for birds; some lobsters, soft shell clams, patchy distribution.
Not clearly an EBSA, much discussion on whether there is sufficient evidence for this attribute.

Area	Fitness Consequences
Quoddy Region	1 yes. Herring feeding grounds are significant for the entire Bay of Fundy. 2 yes. Globally important staging area for phalaropes. Continentally significant for other birds 3 yes. Globally important feeding area for whales. Missing nursery areas for lobster (especially Back Bay to Pt. Lepreau) Yes.
St. Croix/ Passamaquoddy Sam Orr's Pond Tongue Shoal	References 1, 2, 3, 4, 5, 6. St Croix # 1 – yes, fitness consequences for birds; locally important (but there are other important areas for birds in Passamaquoddy Bay) Passamaquoddy Bay - # 1 - # 4: in general is important staging area for birds (may be more appropriate to discuss on regional scale). # 5 - Birch Cove mentioned but all shallow water habitats in area are important to lobster. Significant for Quoddy Region but not considered significant for whole Bay of Fundy. # 7 - Cod spawning – there are no records on when this last occurred in Passamaquoddy Bay. This is a historical feature. The group wondered if we can justify this as important if it can't be recovered. # 8 - The group asked if spawning habitat could be recovered.
Head Harbour (West Isles)	# 1 yes; important at local scale and impacts Bay of Fundy. # 2 yes – even if phalaropes don't come back, still important to Bonapartes – probably global scale impacts. # 2, 3, 4, 5, 6 - Area is globally important for birds. Cormorants move around. Individual islands – White Horse really stands out – southern-most kittiwake colonies also the only place puffins or gannets have nested. May be related to lower disturbance / more isolated.

7 – sponges: is this unique to area or just more sampled here? Do sponge communities affect fitness or could other habitat types serve same purpose just as well?
#8 lobster, yes. Locally and regionally (Quoddy) (but not important over whole Bay of Fundy).
9 - One of the most important features of Head Harbour (HH) region. Huge collections of filter feeders are a result of plankton productivity (all linked together); upwelling of plankton relates to huge benthic abundance. This area is important on a global scale to fish, whales, many species at risk, etc.
Big Yes.

The Passages	Currents here have obvious fitness consequences locally. In Quoddy Region affects upwelling outside (HH), and brings energy into Passamaquoddy Bay. High currents keep diversity low but .abundance is high. Driver of upwellings and productivity outside in HH (and has affect over whole Bay of Fundy (affects herring / mackerel growth in late summer). If anything is perturbed here by use of bottom gear it would impact the biology of the Quoddy Region. # 1 is most important. # 2 - reductions in sea urchins may keep sea cucumber up (more localized effect). # 3 Bay of Fundy/Global effect Big Yes.
The Wolves	# 1, 2, & 5 birds. Yes, important links for wintering / breeding birds including harlequin duck – national impact. #3 - may be historic. Lobster breeding – locally important. #6 – whales and other production related to currents. Missing what fitness components relate to aggregations of fish? Yes.
Maces Bay	# 6 & # 7 Lobster – Yes, important area for lobster undisputed. Important to whole Quoddy Region and maybe surrounding area on the basis of this. Scallop nursery ground important locally but unknown importance to whole region. Good urchin production (very few urchins found further up the bay). Roe quality higher at Maces Bay (is this related to some fitness consequence). Birds # 1 – # 4 yes; Maces Bay very exposed; different environment from other areas.

4. Additional points from Day 2 plenary discussion

Each discussion group was provided with summary notes and asked to do a final review and make any changes, additions, etc. that they felt were necessary to complete their work.

This session also involved discussion of the two secondary dimensions, naturalness and resilience. On Day 1 there had been some limited consideration of these secondary dimensions. For the purpose of these proceedings, Day 1 and Day 2 comments have been consolidated.

• Naturalness - the extent to which an area is free of impacts that are the result of human activity. Is it more likely to find endangered species in areas that have high naturalness? It may be argued that there is no such thing as a natural area any more. It was suggested that natural could be used to describe an area under arctic ice that has had no visitation.

• Resilience - the ability to respond to a disturbance and return to an original state. This will be linked to the boundaries that are used to describe and area. The question was asked if resilience is the same as recoverability. Concern was expressed that identification of an area as having a high degree or resilience would be an invitation to open the door to more human activity. It could become an invitation to development. Determining resilience requires a strong science base. A system with slow-growing organisms will be more vulnerable and less resilient. The question was asked "how much time it takes for the system to 'reset'".

• Perturbation - while this was touched on several times during the Day 2 morning discussions, it was noted that it is not perturbation that needs to be clarified and considered, but rather the secondary dimension of resilience, which is the capacity of an ecosystem to respond.

• Connectivity - this was noted to be especially important for the Quoddy Region. This refers to the dependence of critical areas such as Head Harbour/West Isles and The Passages on their surroundings (e.g. Passamaquoddy Bay). The surrounding areas perform critical functions but may not, in and of themselves, be considered EBSAs. Good connectivity can enhance resilience. Some areas (hot spots) feed resources (energy, nutrients, larvae, juveniles) to other areas.

• Irreplaceability - this was noted to be the biggest "red flag" - for example, there is only one Bay of Fundy/Gulf of Maine.

• Refugia - it was suggested that the high priority areas had been refugia in the past for multiple species, some of which may have had negative impacts from human activity.

5. Workshop Agenda

Day 1 – Monday February 25th 2008

8:30	Coffee
9:00	Welcome, Introductions, Agenda Review (Bruce) Workshop Background and Introduction
9:30	EBSA Overview Presentation and Discussion (Penny)
10:00	Quoddy Presentation and Discussion (Maria)
10:30	Break
10:45	Review of Draft Technical Report (Maria, All) - questions and discussion
11:45	Objectives and format of afternoon discussion (Bruce & Maria) - objectives of review and role of participants - explanation of discussion format and summary table
12:00	Lunch
1:00	Small Group Discussions (All) - apply individual EBSA criteria to specific areas - one group per criteria
2:30	Break
3:00	Small Group Discussion (continued) - apply individual criteria to specific areas
4:30	Wrap-up for the Day (Bruce) - groups submit summary of discussions and assignment of criteria

Day 2 – Tuesday February 26th 2008

9:00	Review Day 1 Results (Bruce, All) - finalize results for six areas - discuss naturalness and resilience
10:15	Break
10:30	Consider Conclusions and Recommendations (All) - next Steps - wrap-up
12:00	Evaluation and Adjourn

6. Workshop participant list

In attendance	Affiliation	Email
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